```
      PROGRAM POWERWORLD
C
C ************************************************************************
C                        LOADMATCH GRID INTEGRATION MODEL
C       MATCHES ALL-ENERGY DEMAND WITH SUPPLY, STORAGE, AND DEMAND RESPONSE
C CONTINUOUSLY, AVOIDING BLACKOUTS, IN STATES, ISLANDS, COUNTRIES, CONTINENTS
C ************************************************************************
C                           COMPILE IN DOUBLE PRECISION
C               ifort -save -O2 -r8 -i8 -mcmodel=large powerworld.f
C               gfortran -fdefault-real-8 -fdefault-double-8 powerworld.f
C ************************************************************************
C ************************************************************************
C               WRITTEN BY MARK Z. JACOBSON (JACOBSON@STANFORD.EDU)
C                       STANFORD UNIVERSITY (1-650-723-6836)
C            FIRST CODING: NOV. 10, 2014. LAST UPDATE: MARCH 6, 2024
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C ************************************************************************
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C THE SOURCE OF THE PROGRAM IN ALL PUBLICATIONS THAT MAKE USE OF SUCH
C INFORMATION. THE USER ALSO AGREES TO ADDRESS ANY QUESTIONS OR UNCERTAINTIES
C                   TO MZJ (JACOBSON@STANFORD.EDU) PRIOR TO PUBLICATION.
C ************************************************************************
C REFERENCES:
C ************************************************************************
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C  REGIONS WITH 100% INTERMITTENT WIND, WATER, AND SUNLIGHT (WWS) FOR ALL
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C
C ***************************************************************************
C                           LOADMATCH MODEL, VERSION XII
C ***************************************************************************
C VERSION I FOR 48 CONTINENTAL U.S. STATES BY MZJ STARTING NOVEMBER 10, 2014
C VERSION II FOR 139 COUNTRIES IN 20 WORLD REGIONS BY MZJ STARTING AUGUST 23, 2015
C VERSION III FOR 143 COUNTRIES IN 24 WORLD REGIONS BY MZJ STARTING JUNE 28, 2019
C VERSION IV 143 COUNTRIES, W/BUILDING HEAT/COLD LOADS GATOR-GCMOM START MAY 25, 2020
C VERSION V FOR INDIVIDUAL AND COMBINED EUROPEAN COUNTRIES STARTING NOV 4, 2020
C VERSION VI FOR INDIVIDUAL CANARY ISLANDS STARTING NOV 18, 2020
C VERSION VII FOR THE 50 U.S. STATES & DC BY MZJ STARTING JAN 2, 2021
C VERSION VIII FOR 145 COUNTRIES/24 WORLD REGIONS BY MZJ STARTING JUN 21, 2021
C VERSION IX WITH H2 FOR STEEL, AMMONIA, LONG-DIST TRANSPORT BY MZJ START AUG 4 2022
C VERSION X WITH H2 FOR GRID ELECTRICITY BY MZJ START FEB 16 2023
C VERSION XI FOR 149 COUNTRIES/29 WORLD REGIONS BY MZJ STARTING JUL 14, 2023
C VERSION XII WITH FIREBRICKS FOR INDUSTRY BY MZJ STARTING JAN 26, 2024
C
C ***************************************************************************
C THIS PROGRAM CHECKS WHETHER TIME-DEPENDENT WWS DEMAND IN A STATE, MULTISTATE REGION,
C ISLAND, MULTI-ISLAND REGION, COUNTRY, OR MULTI-COUNTRY REGION CAN BE
C MET 100% OF THE TIME (EVERY 30 SEC FOR 1 OR MORE YEARS) BY WWS SUPPLY FROM WIND,
C SOLAR, GEOTHERMAL, HYDROELECTRIC, TIDAL, & WAVE, COMBINED WITH ELECTRICITY,
C HEAT, COLD, AND HYDROGEN STORAGE AND DEMAND-RESPONSE, ASSUMING A PERFECT
C TRANSMISSION GRID. ESTIMATED ALL-DISTANCE TRANSMISSION & DISTRIBUTION COSTS &
C LOSSES ARE ACCOUNTED FOR.
C
C WIND INCLUDES ONSHORE AND OFFSHORE WIND; SOLAR INCLUDES ROOFTOP PV, UTILITY
C PV, CSP, AND SOLAR THERMAL FOR HEAT. GEOTHERMAL INCLUDES GEOTHERMAL FOR
C ELECTRICITY AND SEPARATELY, FOR HEAT.
C
C THE 3-D GLOBAL-THROUGH-LOCAL GATOR-GCMOM (GAS, AEROSOL, TRANSPORT, GENERAL-
C CIRCULATION, MESOSCALE, AND OCEAN MODEL)  PRODUCES WIND AND SOLAR OUTPUT AT
C THE LOCATION OF EACH ONSHORE AND OFFSHORE WIND FARM, PV AND CSP POWER
C PLANT, ROOFTOP PV SYSTEM, AND SOLAR THERMAL HEAT SYSTEM. GATOR-GCMOM
C ALSO PRODUCES HEAT & COLD LOADS IN GATOR-GCMOM MODEL GRID CELL IN
C EACH COUNTRY (JACOBSON, 2021, SMART ENERGY)
C ALL LOCATION-SPECIFIC VALUES ARE THEN AGGREGATED WITHIN EACH MODEL
C GRID CELL TO THE LAT/LON AT THE CELL HORIZONTAL CENTREY EVERY 30 SEC
C THE DATA FROM EACH GRID CELL IN GATOR-GCMOM ARE THEN AGGREGATED TO
C PRODUCE STATE, ISLAND, OR COUNTRY-AGGREGATED VALUES OF EACH ONSHORE WIND,
C OFFSHOREE WIND, UTILITY PV, CSP, ROOFTOP PV, AND SOLAR THERMAL FOR HEAT
C IN FILE wwssupworld.dat. THE STATE, ISLAND, AND COUNTRY VALUES ARE
C EITHER FED RIGHT INTO LOADMATCH OR AGGREGATED INTO REGIONS THAT ARE
C FED INTO LOADMATCH. LOADMATCH ALSO INCORPORATES
C GEOTHERMAL, HYDROELECTRIC, TIDAL, AND WAVE PRODUCTION VALUES FROM
C countrystats.dat.
C
C THE NUMBERS OF WIND TURBINES, PV & CSP PLANTS, ROOFTOP AND SOLAR HEAT SYSTEMS,
C GEOTHERMAL PLANTS, HYDROELECTRIC PLANTS, AND TIDAL AND WAVE DEVICES ARE
C PROVIDED IN countrystats.dat AND DETERMINED FROM A SPREADSHEET DESCRIBED IN THE
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C PAPERS ABOVE AS WELL AS IN ROADMAP STUDIES, INCLUDING
C
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C  (WWS) ALL SECTOR ENERGY ROADMAPS FOR 139 COUNTRIES OF THE WORLD, JOULE, 1,
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C  (WWS) ALL-SECTOR ENERGY ROADMAPS FOR THE 50 UNITED STATES, ENERGY
C  AND ENVIRONMENTAL SCIENCES, 8, 2093-2117, DOI:10.1039/C5EE01283J,
C  2015.
C
C IN THIS PROGRAM:
C WHEN OVERGENERATION OCCURS, THE EXCESS IS STORED AS ELECTRICITY, HEAT,
C   OR COLD OR USED TO PRODUCE HYDROGEN.
C WHEN UNDERGENERATION OCCURS, STORED ELECTRICITY, HEAT, COLD, OR H2 IS USED
C   TO SUPPLY INFLEXIBLE LOADS FIRST THEN FLEXIBLE LOADS.
C FLEXIBLE LOADS NOT MET IMMEDIATELY ARE SHIFTED FORWARD IN TIME 30 SEC
C   AT A TIME DUE TO DEMAND-RESPONSE, BUT ONLY BY UP TO 8 HOURS AT WHICH POINT THEY
C   ARE TURNED TO INFLEXIBLE LOADS.
C HYDROGEN LOAD IS MET FROM STORAGE OR CURRENT ELECTRICITY.
C SEVERAL TYPES OF STORAGE ARE USED FOR HEAT, COLD, AND ELECTRICITY.
C
C NO FAILURE IS PERMITTED TO  OCCUR.
C
C ***************************************************************************
C MODEL SWITCHES
C   IFREWRITE,  IFCONUS,  GRIDUSE,  INITYLOAD, IFINYLOAD, IBEGYLOAD,
C   ISUPYEAR,   IFGATHEAT NYEARS,   IFHRLOAD,  IFCANARY,  IFSTATES,
C   IMERGH2,    IFHEATBAT
C
C MODEL PARAMETERS TO VARY HERE FOR BOTH 50 STATES AND 145 COUNTRIES
C   FACONWIN,   FACOFFWIN,  FACRESPV, FACCOMPV, FACUTILPV,  FACSHT
C   CSPTURBFAC, CSPSTORGAT, MXHRDRM
C   BATDISCH,   HCHARCSP,   STORHBAT
C   STORHCOLD,  STORHHWAT,  STORHPHS,
C   UGFAC,      STORUGDYS,  DAYH2STOR
C   HPTURBRAT,  DAMCAPRAT,  DAYBASHYD
C   COOLSTES,   PHSMIN,     FHEATFLX
C   FCOLDFLX,   FRSTORINIT, FDISTHEAT
C   CPERFORM,   HCDDADD,    FMORTBAU
C   HWFAC,      FCDISCH,    FCCHARG,
C   STORHHFC,   HBTDISCH,   STORHHBT
C   FRCIHFLEX
C
C PARAMETERS FROM STATE OR COUNNTRY PAPERS
C   CAP2019LO, CAP2019HI
C   CAP2050LO, CAP2050HI
C   TDLOSLO,   TDLOSHI
C   SDTRCOSL,  STDTRCOSH
C   RATIOCSPDAT
C
C PARAMETERS TO UPDATE WHEN UPDATING LOAD DATASETS FOR 50-STATES.
C VALUES AUTOMATICALLY OBTAINED FROM countrystats.dat (EXCEPT CHECK
C TWONSHGAT... IN CASE THE CURRENT VALUE IS OUTDATED)
C   TGWONWIND, TGWOFFWIND, TGWRESPV,  TGWCOMPV...
C   TWONSHGAT, TWOFFSHGAT, TWROOFPVG, TWUTILPVG, TWCSPGAT, TWSHTGAT
C   EGWONWIND, EGWOFFWIND, EGWRESPV,  EGWCOMPV...
C   CURGEOEL,  CURHYD,     CURTID,    CURWAV
C   BLOADRES,  BLOADCOM,   BLOADIND,  BLOADTRA,  BLOADAGF,  BLOADOTH
C   FRACLOAD,  PDENINST,
C   FRACREH2,  FRACCOH2,   FRACTRH2,  FRACINH2
C
C ***************************************************************************
C NYEARS   = ACTUAL NUMBER OF YEARS OF SIMULATION (1..ANY NUMBER NOW)
C
C     PARAMETER(NYEARS   = 1)
C     PARAMETER(NYEARS   = 2)
      PARAMETER(NYEARS   = 3)
C     PARAMETER(NYEARS   = 4)
C     PARAMETER(NYEARS   = 5)
C     PARAMETER(NYEARS   = 6)
C
C MXYEAR   = MAXIMUM NUMBER OF YEARS OF SIMULATION >= NYEARS TO
C            ENSURE SOME DATA ARE PRINTED OUT OVER MULTIPLE YEARS EVEN
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C            THOUGH SIMULATIONS ARE FOR FEWER YEARS. SET TO SOME HIGH #
C
      PARAMETER(MXYEAR   = 6)
C
C MXHPDAY   = NUMBER OF HOURS PER DAY (24)
C MXMONTH   = MAX NUMBER OF MONTHS PER YEAR
C MXDAYYR   = MAX NUMBER OF DAYS PER YEAR (366, TO ACCOUNT FOR LEAP YEARS)
C NDAYDATA  = NUMBER OF DAYS OF COOLING/HEATING DEGREE DAY DATA FROM KHDD FILE.
C             DATA START JAN 1, 2013 TO DEC 31, 2014 (NON-LEAP YEARS)
C MXHPYEAR  = NUMBER OF HOURS PER YEAR FOR LEAP YEARS = 8784
C MXLOAD    = MAX NUMBER OF HOURS PER YEAR FOR LOAD DATA
C MXWWS     = MAX NUMBER OF TIME ENTRIES IN FILE KWWS
C MXDAY     = MAX POSSIBLE NUMBER OF DAYS OF SIMULATION = MXDAYYR * NYEARS
C             ACTUAL NUMBER OF DAYS = NDSIM
C MXLOADYR  = MAX NUMBER OF HOURS OF LOAD DATA USED OVER NYEARS OF SIMULATION
C MXHRSIM   = MAX NUMBER OF GMT HOURS PER SIMULATION
C MXYLOAD   = MAX NUMBER OF YEARS OF ENTSOE LOAD DATA (11 = 2006 TO 2016) IN FILES
C MXYHRLOAD = MAX NUMBER OF YEARS OF HI-RES LOAD DATA IN FILE
C MXTSPYR   = MAX NUMBER OF 30-SECOND TIME STEPS PER YEAR
C             FOR NON-LEAP YEARS, IT IS 1,051,200 =8760 HRS/YRx120 30-S/HR
C MXTSHRALL = MAX NUMBER 30-SEC TIME STEPS IN ALL YEARS OF SIMULATION
C MXREGUS   = MAX NUMBER OF U.S. REGIONS FOR WHICH LOAD DATA AVAILABLE
C MXHLOADUS = MAX NUMBER OF HOURS OF U.S. LOAD DATA (2016-19) = 4 * 8784
C
      PARAMETER(MXHPDAY   = 24)
      PARAMETER(MXMONTH   = 12)
      PARAMETER(MXDAYYR   = 366)
      PARAMETER(NDAYDATA  = 365 * 2)
      PARAMETER(MXHPYEAR  = MXHPDAY * MXDAYYR)
      PARAMETER(MXLOAD    = MXHPYEAR)
      PARAMETER(MXWWS     = 15000000)
      PARAMETER(MXDAY     = MXDAYYR  * NYEARS)
      PARAMETER(MXLOADYR  = MXLOAD   * NYEARS)
      PARAMETER(MXHRSIM   = MXHPYEAR * NYEARS)
      PARAMETER(MXYLOAD   = 11)
      PARAMETER(MXYHRLOAD = 1)
      PARAMETER(MXTSPYR   = MXHPYEAR * 120)
      PARAMETER(MXTSHRALL = MXTSPYR * NYEARS)
      PARAMETER(MXREGUS   = 14)
      PARAMETER(MXHLOADUS = 4*MXHPYEAR)
C
C MXCAP     = MAX NUMBER OF GENERATORS FOR WHICH CAPITAL COSTS AVAILABLE
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEO
C             HYDRO  TIDAL   WAVE  SOLTHERM
C MXSTOR    = MAX NUMBER OF NON-UTES STORAGE TYPES CONSIDERED
C MXSECTOR  = MAX NUMBER OF LOAD SECTORS FOR COUNTRY PLANS (6)
C             RESIDENTIAL, COMMERCIAL, TRANSPORTATION, INDUSTRY,
C             AGRICULTURE/FORESTRY/FISHING, OTHER
C MXJOBCAT  = MAXIMUM NUMBER OF JOB CATEGORIES
C MXSTORJOB = MAX TYPES OF STORAGE FOR JOB CALCULATIONS
C
      PARAMETER(MXCAP     = 13)
      PARAMETER(MXSTOR    = 8)
      PARAMETER(MXSECTOR  = 6)
      PARAMETER(MXJOBCAT  = 14)
      PARAMETER(MXSTORJOB = 10)
C
C MXGRIDS   = MAX NUMBER OF GRID REGIONS OF THE WORLD
C             ADD 1 WHEN BREAKING REGIONS INTO INDIVIDUAL COUNTRIES
C             ADD 38 WHEN SEPARATING ALL COUNTRIES OF EUROPE
C               SERBIA+MONTENEGRO+KOSOVO TREATED AS ONE IN GATOR-GCMOM
C MXCOUNTRY = MAX NUMBER OF COUNTRIES READ IN
C MXCOUNHDD = MAX NUMBER OF COUNTRIES READ IN heatcooldd.dat
C             INCLUDES THOSE FROM CANARY ISLANDS
C
      PARAMETER (MXGRIDS   = 29)
C     PARAMETER (MXGRIDS   = 29+1)
C     PARAMETER (MXGRIDS   = 29+38)
      PARAMETER (MXCOUNTRY = 149)
      PARAMETER (MXCOUNHDD = MXCOUNTRY + 6)
C
C NDAYYR   = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C NHYEAR   = NUMBER OF HOURS PER YEAR OF SIMULATION (EITHER 8760 OR 8784)
C
      DIMENSION TIMLOAD(MXLOADYR), BLOAD(   MXLOADYR)
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 DIMENSION HOTHOUR(MXLOADYR), COLDHOUR(MXLOADYR)
 DIMENSION TIMORIG(  MXWWS)
 DIMENSION TIMWWS(   MXWWS)
 DIMENSION IYRWWS(   MXWWS)
 DIMENSION EXTRACSP( MXWWS)
 DIMENSION CURONSH(  MXWWS), CUROFFSH(MXWWS)
 DIMENSION CUROOFPV( MXWWS), CURUTPV( MXWWS), CURCSP(MXWWS)
 DIMENSION CURWAVP(  MXWWS), CURSOLHT(MXWWS)
 DIMENSION CURHLOAD( MXWWS), CURCLOAD(MXWWS)
 DIMENSION CURHFLEX( MXWWS), CURCFLEX(MXWWS), CURVFLEX(MXWWS)
 DIMENSION CURFLOAD( MXWWS)
 DIMENSION CINFXHLD( MXWWS), CINFXCLD(MXWWS), CINFXVEH(MXWWS)
 DIMENSION CURGEOP(  MXWWS), CURTIDP( MXWWS)
 DIMENSION CURGEOH(  MXWWS)
 DIMENSION CURHEAT(  MXWWS), CURCOLD( MXWWS)
 DIMENSION FSTPWARM( MXWWS), FSTPCOOL(MXWWS), FSTPVEH(MXWWS)
 DIMENSION CLOAD(    MXWWS), PERHRS(  MXWWS)
 DIMENSION SUPPLY(   MXWWS), DEMAND(  MXWWS)
 DIMENSION SUPPHT(   MXWWS)
 DIMENSION SUMONWIND(MXWWS)
 DIMENSION SUMOFWIND(MXWWS)
 DIMENSION SUMROOFPV(MXWWS)
 DIMENSION SUMUTILPV(MXWWS)
 DIMENSION SUMCSP(   MXWWS)
 DIMENSION SUMSTHERM(MXWWS)
 DIMENSION SUMHEAT(  MXWWS)
 DIMENSION SUMCOLD(  MXWWS)
 DIMENSION HRINFLX(MXHPDAY,MXDAY),
1          HRONWIN(MXHPDAY,MXDAY),
1          HROFFWD(MXHPDAY,MXDAY),
1          HRROOF( MXHPDAY,MXDAY),
1          HRUTPV( MXHPDAY,MXDAY),
1          HRCSP(  MXHPDAY,MXDAY),
1          HRSUPP( MXHPDAY,MXDAY),
1          HRCNT(  MXHPDAY,MXDAY),
1          HRFLXLD(MXHPDAY,MXDAY),
1          PKSUPE( MXHPDAY,MXDAY),
1          PKDEME( MXHPDAY,MXDAY),
1          TOTSUPP(MXHPDAY,MXDAY),
1          TOTDEMD(MXHPDAY,MXDAY),
1          HRCOUNT(MXHPDAY,MXDAY),
1          ORIGLD( MXHPDAY,MXDAY)
 DIMENSION HRSHT( MXHPDAY,MXDAY)
 DIMENSION HRGHT( MXHPDAY,MXDAY)
 DIMENSION HRHYDR(MXHPDAY,MXDAY)
 DIMENSION HRWAVE(MXHPDAY,MXDAY)
 DIMENSION HRGEOT(MXHPDAY,MXDAY)
 DIMENSION HRTIDE(MXHPDAY,MXDAY)
 DIMENSION HCSTOR(MXHPDAY,MXDAY)
 DIMENSION HCSTLS(MXHPDAY,MXDAY)
 DIMENSION HCSTLI(MXHPDAY,MXDAY)
 DIMENSION PHSTOR(MXHPDAY,MXDAY)
 DIMENSION PHSTLS(MXHPDAY,MXDAY)
 DIMENSION PHSTLI(MXHPDAY,MXDAY)
 DIMENSION HOSTOR(MXHPDAY,MXDAY)
 DIMENSION HOSTLS(MXHPDAY,MXDAY)
 DIMENSION HOSTLI(MXHPDAY,MXDAY)
 DIMENSION HTSTOR(MXHPDAY,MXDAY)
 DIMENSION HTSTLS(MXHPDAY,MXDAY)
 DIMENSION HTSTLI(MXHPDAY,MXDAY)
 DIMENSION HBSTOR(MXHPDAY,MXDAY)
 DIMENSION HBSTLS(MXHPDAY,MXDAY)
 DIMENSION HBSTLI(MXHPDAY,MXDAY)
 DIMENSION HFSTOR(MXHPDAY,MXDAY)
 DIMENSION HFSTLS(MXHPDAY,MXDAY)
 DIMENSION HFSTLI(MXHPDAY,MXDAY)
 DIMENSION BRSTOR(MXHPDAY,MXDAY)
 DIMENSION BRSTLS(MXHPDAY,MXDAY)
 DIMENSION BRSTLI(MXHPDAY,MXDAY)
 DIMENSION UGSTOR(MXHPDAY,MXDAY)
 DIMENSION UGSTLS(MXHPDAY,MXDAY)
 DIMENSION UGSTLI(MXHPDAY,MXDAY)
 DIMENSION HRTDLS(MXHPDAY,MXDAY)
 DIMENSION HRSHED(MXHPDAY,MXDAY)
 DIMENSION H2STOR(MXHPDAY,MXDAY)
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      DIMENSION COLDHR(MXHPDAY,MXDAY)
      DIMENSION WARMHR(MXHPDAY,MXDAY)
      DIMENSION H2LOAD(MXHPDAY,MXDAY)
      DIMENSION VEHPROF(MXHPDAY), VEHRAT(MXHPDAY)
      DIMENSION HDDMON( MXMONTH), CDDMON(MXMONTH)
      DIMENSION DAYFLEX(MXDAY), TWARMDAY(MXDAY), TCOOLDAY(MXDAY)
      DIMENSION H2FLEX( MXDAY)
      DIMENSION REMAINHR(MXHRSIM), NTIMSTEPS(MXHRSIM)
      DIMENSION IGMTM(  MXDAY+1)
      DIMENSION IDYR(   MXDAY+1)
      DIMENSION CAP2019LO(MXCAP), CAP2019HI(MXCAP),
     1          CAP2050LO(MXCAP), CAP2050HI(MXCAP)
      DIMENSION AGWINSTAL(MXCAP), PGWINSTAL(MXCAP)
      DIMENSION OANDMLO(  MXCAP), OANDMMN(  MXCAP), OANDMHI(  MXCAP)
      DIMENSION DECOMLO(  MXCAP), DECOMMN(  MXCAP), DECOMHI(  MXCAP)
      DIMENSION ANNFACL(  MXCAP), ANNFACM(  MXCAP), ANNFACH(  MXCAP)
      DIMENSION ACAPCOSL( MXCAP), ACAPCOSM( MXCAP), ACAPCOSH( MXCAP)
      DIMENSION PCAPCOSL( MXCAP), PCAPCOSM( MXCAP), PCAPCOSH( MXCAP)
      DIMENSION YEARLIFEL(MXCAP), YEARLIFEM(MXCAP), YEARLIFEH(MXCAP)
      DIMENSION TDLOSLO(  MXCAP), TDLOSMN(  MXCAP), TDLOSHI(  MXCAP)
      DIMENSION SDTRCOSL( MXCAP), SDTRCOSM( MXCAP), SDTRCOSH( MXCAP)
      DIMENSION TDEFFMN(  MXCAP), TDRATMN(  MXCAP), FRACLOAD( MXCAP)
      DIMENSION AVCAPLO(  MXCAP), AVCAPMN(  MXCAP), AVCAPHI(   MXCAP)
      DIMENSION PDENINST( MXCAP)
      DIMENSION ALLTONEW( MXCAP)
      DIMENSION GWFINAL(  MXCAP)
      DIMENSION GWNEW(    MXCAP)
      DIMENSION COSTSTORL(MXSTOR), COSTSTORM(MXSTOR), COSTSTORH(MXSTOR)
      DIMENSION LDMONTH(MXYEAR,MXMONTH)
      DIMENSION NDAYYR(MXYEAR)
      DIMENSION NHYEAR(MXYEAR)
      DIMENSION NHCUM( MXYEAR)
      DIMENSION AVCOLDLD(MXYEAR)
      DIMENSION AVHEATLD(MXYEAR)
      DIMENSION AVWINPOW(MXYEAR)
      DIMENSION HRSINYR( MXYEAR)
      DIMENSION AMAXLOAD( MXYEAR), AMINLOAD( MXYEAR)
      DIMENSION RAMPMAX(  MXYEAR), TIMAXRAMP(MXYEAR)
      DIMENSION TIMAXLOAD(MXYEAR), TIMINLOAD(MXYEAR)
      DIMENSION HDDYR( NYEARS)
      DIMENSION CDDYR( NYEARS)
      DIMENSION ALOADHR( MXHPYEAR,MXYLOAD)
      DIMENSION ALOADREG(MXHPYEAR,MXYLOAD)
      DIMENSION YRLOAD(  MXYLOAD)
      DIMENSION ILOADMW( MXYLOAD)
      DIMENSION IYOFLOAD(MXYLOAD)
      DIMENSION STORLOAD(MXCOUNTRY,MXHPYEAR)
      DIMENSION IFUSED(  MXCOUNTRY,MXHPYEAR)
      DIMENSION READLOAD(MXHPYEAR)
      DIMENSION ILOADCOUN(MXCOUNTRY)
      DIMENSION STORCJOB(MXSTORJOB)
      DIMENSION STOROJOB(MXSTORJOB)
      DIMENSION BLOADMW(MXYHRLOAD)
      DIMENSION YLOADHR(MXYHRLOAD)
      DIMENSION IYOFHRLD(MXYHRLOAD)
      DIMENSION HRESLOAD(MXTSPYR,MXYHRLOAD)
      DIMENSION DLOAD(   MXTSHRALL)
      DIMENSION TLOADHR( MXTSHRALL)
      DIMENSION USALOAD( MXHLOADUS,MXREGUS)
C
C NUMGRIDS   = NUMBER OF GRID REGIONS IN countrystats.dat FILE
C NAMEGRID   = 1..NUMGRIDS NAME OF ALL GRID REGIONS IN countrystats.dat FILE
C SUMWWS     = SUM OF END-USE LOAD (GW) OVER ALL COUNTRIES IN 1..MXGRIDS REGION
C SUMH2REG   = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C              OVER ALL COUNTRIES AND SECTORS IN GRID REGION J
C NCOUNGRID  = NUMBER OF COUNTRIES IN EACH 1..NUMGRIDS GRID REGION
C NAMORIGGR  = ORIG COUNTRY NAME OF EACH 1..NCOUNGRID COUNTRY
C              OF EACH 1..NUMGRIDS REGION
C NAMCOUNGR  = FINAL COUNTRY NAME OF EACH 1..NCOUNGRID COUNTRY
C              OF EACH 1..NUMGRIDS REGION
C NUMCOUNGR  = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C              OF EACH 1..NUMGRIDS REGION
C TLOADSUM   = SUM OF TLOADSEC (GW) AMONG COUNTRIES IN EACH J=1..NUMGRIDS REGION
C H2SECGRID  = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C              OVER ALL COUNTRIES IN GRID REGION J FOR SECTOR K
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C TSECALL    = SUM OF TLOADSEC (GW) AMONG ALL COUNTRIES OVER ALL GRID REGIONS
C H2SECALL   = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C              OVER ALL COUNTRIES IN SECTOR K
C NCOUNTRY   = NUMBER OF COUNTRIES READ IN DATASET
C WWSTOT     = TOTAL 2050 END-USE LOAD (GW) FOR EACH 1..MXCOUNTRY COUNTRY
C SUPALL     = 2050 TOTAL POWER SUPPLY (GW) ALL ELEC POW SOURCES (NOT SUPGHT2050)
C NAMEORIG   = NAME OF 1..NCOUNTRY AS READ FROM countrystats.dat
C              THIS NAME IS CHANGED BELOW TO MATCH THOSE FROM wwssupworld.dat
C NAMECOUN   = FINAL NAME OF EACH 1..NCOUNTRY COUNTRY
C              NAMECOUN NAMES MATCH COUNTRY NAMES FROM wwssupworld.dat
C GRIDCOUN   = NAME OF EACH 1..NCOUNTRY GRID REGION THE COUNTRY LIES IN
C TGWINSTALL = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY IN 2050
C TGWINSTGAT = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY GATOR-GCMOM SIMS
C EGWINSTALL = EXISTING INSTALLED GW OF EACH 1..MXCAP DEVICE
C SUP2050    = 2050 ELECTRIC POWER (NOT HEAT) SUPPLY (GW) BY 1..MXCAP DEVICE
C FLOADREG   = FRAC 2050 END USE ELEC POWER FROM EACH 1..MXCAP DEVICE IN REGION
C TLOADSEC   = 2050 END-USE LOAD (GW) FOR EACH 1..MXSECTOR SECTOR BY COUNTRY
C FRCH2SEC   = FRACTION OF END-USE POWER DEMAND EACH 1..MXSECTOR SECTOR
C              GOING TO H2 ELECTROLYSIS/COMPRESSION/STORAGE
C FRCH2REG   = FRACTION OF END-USE POWER DEMAND EACH 1..MXSECTOR SECTOR
C              IN EACH 1..NUMGRIDS GRID GOING TO H2 ELECTROL/COMPRESSION/STORAGE
C FELECSEC   = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECRICITY.
C              THE REST GOES TO HEAT.
C FELECREG   = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C              IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C
      DIMENSION NAMEGRID(  MXGRIDS)
      DIMENSION NAMELOAD(  MXCOUNTRY)
      DIMENSION NCOUNGRID( MXGRIDS)
      DIMENSION SUMWWS(    MXGRIDS)
      DIMENSION SUMH2REG(  MXGRIDS)
      DIMENSION TGWALLREG( MXGRIDS)
      DIMENSION EGWALLREG( MXGRIDS)
      DIMENSION SUPALLREG( MXGRIDS)
      DIMENSION GATALLREG( MXGRIDS)
      DIMENSION REGONWIND( MXGRIDS)
      DIMENSION REGOFWIND( MXGRIDS)
      DIMENSION REGROOFPV( MXGRIDS)
      DIMENSION REGUTILPV( MXGRIDS)
      DIMENSION REGCSP(    MXGRIDS)
      DIMENSION REGSTHERM( MXGRIDS)
      DIMENSION REGHEAT(   MXGRIDS)
      DIMENSION REGCOLD(   MXGRIDS)
      DIMENSION EXISTPHSR( MXGRIDS)
      DIMENSION EXISOLTHR( MXGRIDS)
      DIMENSION AREALKM2R( MXGRIDS)
      DIMENSION BAULOADR(  MXGRIDS)
      DIMENSION BAULCOER(  MXGRIDS)
      DIMENSION BAUHEALR(  MXGRIDS)
      DIMENSION BAUCLIMR(  MXGRIDS)
      DIMENSION AMORTCURR( MXGRIDS)
      DIMENSION AMORT50R(  MXGRIDS)
      DIMENSION AVGCDD(    MXGRIDS)
      DIMENSION AVGHDD(    MXGRIDS)
      DIMENSION TGWADCSPR( MXGRIDS)
      DIMENSION TGWINSTGLB(MXCAP)
      DIMENSION EGWINSTGLB(MXCAP)
      DIMENSION SUPGLOB(   MXCAP)
      DIMENSION GATGLOB(   MXCAP)
      DIMENSION SUMEN(     MXCAP)
      DIMENSION SUMNP(     MXCAP)
      DIMENSION NAMORIGGR( MXGRIDS,MXCOUNTRY)
      DIMENSION NAMCOUNGR( MXGRIDS,MXCOUNTRY)
      DIMENSION NUMCOUNGR( MXGRIDS,MXCOUNTRY)
      DIMENSION TLOADSUM(  MXGRIDS,MXSECTOR)
      DIMENSION H2SECGRID( MXGRIDS,MXSECTOR)
      DIMENSION ELLOADSEC( MXGRIDS,MXSECTOR)
      DIMENSION FRCH2REG(  MXGRIDS,MXSECTOR)
      DIMENSION FELECREG(  MXGRIDS,MXSECTOR)
      DIMENSION TGWINSTREG(MXGRIDS,MXCAP)
      DIMENSION EGWINSTREG(MXGRIDS,MXCAP)
      DIMENSION TGWGATREG( MXGRIDS,MXCAP)
      DIMENSION SUPGWREG(  MXGRIDS,MXCAP)
      DIMENSION FLOADREG(  MXGRIDS,MXCAP)
      DIMENSION TSECALL(   MXSECTOR)
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      DIMENSION H2SECALL(  MXSECTOR)
      DIMENSION WWSTOT(    MXCOUNTRY)
      DIMENSION SUPPALL(   MXCOUNTRY)
      DIMENSION NAMECOUN(  MXCOUNTRY)
      DIMENSION NAMEORIG(  MXCOUNTRY)
      DIMENSION GRIDCOUN(  MXCOUNTRY)
      DIMENSION NAMHTREG(  MXCOUNTRY)
      DIMENSION MAPCOUN(   MXCOUNTRY)
      DIMENSION ISUSED(    MXCOUNTRY)
      DIMENSION EXISTPHSC( MXCOUNTRY)
      DIMENSION EXISOLTHC( MXCOUNTRY)
      DIMENSION AREALKM2C( MXCOUNTRY)
      DIMENSION BAULOADC(  MXCOUNTRY)
      DIMENSION BAULCOEC(  MXCOUNTRY)
      DIMENSION BAUHEALC(  MXCOUNTRY)
      DIMENSION BAUCLIMC(  MXCOUNTRY)
      DIMENSION AMORTCURC( MXCOUNTRY)
      DIMENSION AMORT50C(  MXCOUNTRY)
      DIMENSION FELBUILD(  MXCOUNTRY)
      DIMENSION FELIND(    MXCOUNTRY)
      DIMENSION TGWALLCOUN(MXCOUNTRY)
      DIMENSION TGWADCSPC( MXCOUNTRY)
      DIMENSION TGWINSTALL(MXCOUNTRY,MXCAP)
      DIMENSION TGWINSTGAT(MXCOUNTRY,MXCAP)
      DIMENSION EGWINSTALL(MXCOUNTRY,MXCAP)
      DIMENSION SUP2050(   MXCOUNTRY,MXCAP)
      DIMENSION TLOADSEC(  MXCOUNTRY,MXSECTOR)
      DIMENSION FRCH2SEC(  MXCOUNTRY,MXSECTOR)
      DIMENSION FELECSEC(  MXCOUNTRY,MXSECTOR)
      DIMENSION HDDDAY(    MXCOUNTRY,NDAYDATA)
      DIMENSION CDDDAY(    MXCOUNTRY,NDAYDATA)
      DIMENSION NAMEREAD(  MXCOUNHDD)
      DIMENSION HDDNAT(    MXCOUNHDD)
      DIMENSION CDDNAT(    MXCOUNHDD)
      DIMENSION HDDREG(MXGRIDS,NYEARS,MXDAYYR)
      DIMENSION CDDREG(MXGRIDS,NYEARS,MXDAYYR)
      DIMENSION POWCOUNTRY(MXCOUNTRY,MXCAP)
      DIMENSION ENCOUNTRY( MXCOUNTRY,MXCAP)
      DIMENSION FRDAYCOOL(NYEARS,MXDAYYR)
      DIMENSION FRDAYWARM(NYEARS,MXDAYYR)
      DIMENSION OPJOBSI(MXJOBCAT), OPJOBSC(MXCOUNTRY,MXJOBCAT)
      DIMENSION CONJOBI(MXJOBCAT), CONJOBC(MXCOUNTRY,MXJOBCAT)
      DIMENSION OPJOBSR(MXGRIDS,MXJOBCAT)
      DIMENSION CONJOBR(MXGRIDS,MXJOBCAT)
      DIMENSION AJOBLOSSC(MXCOUNTRY), AJOBLOSSR(MXGRIDS)
      DIMENSION TCONJOBC( MXCOUNTRY)
      DIMENSION TOPJOBC(  MXCOUNTRY)
      DIMENSION CJOBTDC(  MXCOUNTRY)
      DIMENSION OJOBTDC(  MXCOUNTRY)
      DIMENSION CJOBSTORC(MXCOUNTRY)
      DIMENSION OJOBSTORC(MXCOUNTRY)
      DIMENSION CAPCOSC(  MXCOUNTRY)
      DIMENSION ANNCOSC(  MXCOUNTRY)
      DIMENSION CO2E2050C( MXCOUNTRY), CO2E2050R( MXGRIDS)
      DIMENSION SDTRANLENC(MXCOUNTRY), SDTRANLENR(MXGRIDS)
      DIMENSION DEFOPJOB(MXJOBCAT)
C
C COUNTRY = NAME OF COUNTRY READ IN FROM countrystats.dat
C GRIDNAM = NAME OF GRID WHEN READ IN FROM countrystats.dat
C GRIDUSE = NAME OF GRID REGION SIMULATED FOR PRESENT SIMULATION (SET HERE)
C
      CHARACTER(28) PATHHOME
      CHARACTER(28) PATHTEMP, PATHTEM1
      CHARACTER(39) PATHLOAD
      CHARACTER(14) COUNTRY, NAMEGRID, GRIDNAM,  NAMCOUNGR, GRIDUSE,
     1              NAMECOUN,DOMAIN,   NAMEREAD, DUMMY,     GRIDLOAD,
     1              GRIDCOUN,NAMHTREG, NH,       NAMEORIG,  NAMORIGGR,
     1              NAMELOAD,LOADNAME
C
C HDDMON = HEATING DEGREE DAYS PER MONTH (F) CONUS AVERAGE 1949-2011
C        = DEVIATIONS BELOW MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C          ALL DAYS IN MONTH. THIS IS AVERAGE 1949-2011 CONUS
C          TABLE 1.7 EIA  http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf
C
        DATA HDDMON / 917., 732., 593., 345., 159.,  39.,
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     1                 9.,  15.,  77., 282., 539., 817. /
C
C CDDMON = COOLING DEGREE DAYS PER MONTH (F) CONUS AVERAGE 1949-2011
C        = DEVIATIONS ABOVE MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C          ALL DAYS IN MONTH. THIS IS AVERAGE 1949-2011 CONUS
C          TABLE 1.8 EIA  http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf
C
        DATA CDDMON /   9.,   8.,  18.,  30.,  97.,  213.,
     1               321., 290., 155.,  53.,  15.,    7. /
C
C VEHPROF = PERCENT OF DAILY VEHICLE CHARGING OCCURRING EACH HOUR OF
C           DAY. HOUR 1 = 0-1AM LOCAL TIME. VALUES MUST ADD TO 100.
C
C 60% OF CHARGING BETWEEN 11 PM - 7 AM
C
C       DATA VEHPROF / 7.5, 7.5, 7.5, 7.5, 7.5, 7.5, 7.5, 2.5,
C    1                 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5,
C    1                 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 7.5 /
C
C 60% OF CHARGIING BETWEEN 8 AM - 4 PM
C
C       DATA VEHPROF / 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5,
C    1                 7.5, 7.5, 7.5, 7.5, 7.5, 7.5, 7.5, 7.5,
C    1                 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5, 2.5 /
C
C EQUAL CHARGING ALL HOURS OF DAY
C
        DATA VEHPROF / 24*4.1666666666666667 /
C
C CAP2019LO = 2019 LOW CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C             CSPNOST HAS MEAN OF $2.42 (2.07-2.79) MIL/MW SUBTRACTED TO REMOVE
C             STORAGE COST. ASSUME SOLAR THERMAL SAME AS UTILITY PV
C             THUS CAP2019LO(ICSPNOST) = 6.000 - 2.07 = 3.93 $MIL/MW
C             CAP COST SOLAR THERMAL ASSUMES $3600-4000 PER 3.716 M^2 COLLECTOR
C             & 0.7 KW-TH/M2 FOR CUR COST; +SAME SCALING AS UTIL PV FOR 2050 COST
C CAP2019HI = 2019 HI CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C             CAP COST SOLAR THERMAL ASSUMES $3600-4000 PER 3.716 M^2 COLLECTOR
C             & 0.7 KW-TH/M2 FOR CUR COST; +SAME SCALING AS UTIL PV FOR 2050 COST
C CAP2050LO = 2050 LOW CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C             CAP COST SOLAR THERMAL ASSUMES $3600-4000 PER 3.716 M^2 COLLECTOR
C             & 0.7 KW-TH/M2 FOR CUR COST; +SAME SCALING AS UTIL PV FOR 2050 COST
C CAP2050HI = 2050 HI CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C             CAP COST SOLAR THERMAL ASSUMES $3600-4000 PER 3.716 M^2 COLLECTOR
C             & 0.7 KW-TH/M2 FOR CUR COST; +SAME SCALING AS UTIL PV FOR 2050 COST
C
C CSP IS GIVEN WITH AND WITHOUT STORAGE SINCE 50-STATES-WWS-xlsx ASSUMES STORAGE.
C THE ADDITIONAL COST OF STORAGE IS FOR ADDITIONAL MIRRORS TO OVERSIZE
C GENERATION OF HEAT RELATIVE TO RATED POWER OF TURBINE BY A FACTOR OF 3.2.
C COST OF PHASE-CHANGE MATERIAL FOR STORAGE IS INCLUDED.
C
C CAP2019LO(ICSPSTOR) IS NOT USED HERE SINCE STORAGE COST IS CALCULATED
C SEPARATE (COSTSTORL, COSTSTORM, COSTSTORH)
C
C         ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C         HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C
C 2022 LOW, HIGH CAPITAL COST IN 2020 USD FROM 'Cost of delivered electricity' TAB
C 145Countries.xlsx
C
C FOR 149 COUNTRIES 2022
      DATA CAP2019LO
     1    /1.025,2.50, 2.23, 1.20, 0.775, 6.00, 3.50, 4.05,
     1     2.40, 4.50, 4.50, 1.30, 4.05/
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      DATA CAP2019HI
     1    /1.45, 4.00, 2.825,2.16, 1.060, 9.09, 4.00, 6.05,
     1     3.20, 6.50, 8.00, 1.50, 6.05/
C FOR 145 COUNTRIES 2020
C     DATA CAP2019LO
C    1    /1.05, 2.00, 2.525,1.30, 0.895, 6.00, 3.50, 4.05,
C    1     2.40, 4.50, 4.50, 1.30, 4.05/
C     DATA CAP2019HI
C    1    /1.45, 3.50, 2.825,2.16, 1.060, 9.09, 4.00, 6.05,
C    1     3.20, 6.50, 8.00, 1.50, 6.05/
C
C 2050 LOW, HIGH CAPITAL COST IN 2020 USD FROM 'Cost of delivered electricity' TAB
C 145Countries.xlsx
C
C FOR 149 COUNTRIES 2050
      DATA CAP2050LO
     1    /0.648, 1.236, 0.897, 0.538, 0.383, 2.138, 1.247, 3.885,
     1     2.332, 1.397, 1.190, 0.822, 3.885/
      DATA CAP2050HI
     1    /0.917, 1.609, 1.396, 1.167, 0.621, 4.075, 1.793, 4.573,
     1     3.200, 2.316, 2.851, 1.086, 4.573/
C FOR 145 COUNTRIES 2050
C     DATA CAP2050LO
C    1    /0.658, 0.974, 0.994, 0.552, 0.436, 2.082, 1.215, 3.881,
C    1     2.329, 1.352, 1.142, 0.815, 3.881/
C     DATA CAP2050HI
C    1    /0.909, 1.378, 1.376, 1.153, 0.615, 4.003, 1.761, 4.535,
C    1     3.200, 2.256, 2.776, 1.080, 4.535/
C
C TDLOSLO  = LO TRANSMISSION & DISTRIBUTION LOSS (FRACTION) OF OUTPUT ELECTRICITY
C            THIS WILL INCLUDE SHORT- AND LONG-DISTANCE TRANSMISSION LOSSES
C            FROM 145Countries.xlsx 'Demand Shares by tech, WWS' TAB
C            'OVERALL TRANSMISSION AND DISTRIBUTION EFFICIENCY, 2050'
C            ONWIND OFFWIND RESPV  COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO   TIDAL  WAVE  SOLTHERM GEOHEAT
C            ASSUME SOLAR THERMAL SAME AS UTILITY PV
C TDLOSHI  = HI TRANSMISSION & DISTRIBUTION LOSS (FRACTION) OF OUTPUT ELECTRICITY
C            FROM 145Countries.xlsx 'Demand Shares by tech, WWS' TAB
C            'OVERALL TRANSMISSION AND DISTRIBUTION EFFICIENCY, 2050'
C            ONWIND OFFWIND RESPV  COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO   TIDAL  WAVE  SOLTHERM GEOHEAT
C
      DATA TDLOSLO
     1    /0.05,   0.05,   0.01,   0.01,   0.05,   0.05,   0.05,   0.05,
     1     0.05,   0.05,   0.05,   0.02,   0.05 /
C
      DATA TDLOSHI
     1    /0.10,   0.10,   0.02,   0.02,   0.10,   0.10,   0.10,   0.10,
     1     0.10,   0.10,   0.10,   0.04,   0.10 /
C
C SDTRCOSL = LOW  SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C            FROM 145-COUNTRY SPREADSHEET 'Trans. & distribution cost' TAB ROW 5
C            ONWIND OFFWIND RESPV  COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO   TIDAL  WAVE  SOLTHERM GEOHEAT
C SDTRCOSH = HIGH SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C            FROM 145-COUNTRY SPREADSHEET 'Trans. & distribution cost' TAB ROW 5
C            ONWIND OFFWIND RESPV  COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO   TIDAL  WAVE  SOLTHERM GEOHEAT
C
      DATA SDTRCOSL
     1    /1.0,    1.0,    1.0,    1.0,    1.0,    1.0,    1.0,    1.0,
     1     1.0,    1.0,    1.0,    1.0,    1.0  /
C
      DATA SDTRCOSH
     1    /1.1,    1.1,    1.1,    1.1,    1.1,    1.1,    1.1,    1.1,
     1     1.1,    1.1,    1.1,    1.1,    1.1  /
C
C ***************************************************************************
C         VARIABLE PLUS FIXED O&M COSTS FOR WWS AVG BETWEEN NOW & 2050
C      145-COUNTRY PAPER 'COST OF DELIVERED ELECTRICITY' TAB COLUMNS BC-BF
C  GEOTHERMAL ESTIMATED FROM CSP; VARIABLE COSTS OF HYDRO & OFFSHORE IGNORED
C ***************************************************************************
C ONSHORE WIND  $35 -40 /KW/YR
C OFFSHORE WIND $60 -100/KW/YR
C PV-RESIDENT   $25 -30 /KW/YR
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C PV-COMMERCIAL $13 -20 /KW/YR
C PV-UTILITY    $13 -25 /KW/YR
C CSP-W/ STORE  $40 -60 /KW/YR
C CSP-NO STORE  $36 -54 /KW/YR
C GEOTHERMAL    $36 -54 /KW/YR
C HYDRO         $15 -16 /KW/YR
C TIDAL         $50 -200/KW/YR
C WAVE          $140-500/KW/YR
C SOLAR THERMAL $40 -60 /KW/YR
C
C OANDMLO   = LOW VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C OANDMMN   = MEAN VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C OANDMHI   = HI  VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C
      DATA OANDMLO
     1    /35.,  60.,  25.,  13.,  16.5,  40.,  36.,  36.,
     1     15.,  50., 100.,  40.,  36. /
C
      DATA OANDMHI
     1    /40., 100.,  30.,  20.,  22.5,  60.,  54.,  54.,
     1     16., 200., 250.,  60.,  54. /
C
C ************************************************************************
C            DECOMISSIONING COSTS AS FRACTION OF CAPITAL COST
C    145-COUNTRY SPREADSHEET 'COST OF DELIVERED ELECTRICITY' TAB COLUMNS O-P
C ************************************************************************
C DECOMLO = LOW DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMHI = HIGH DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C
C          ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C          HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C
      DATA DECOMLO
     1    / 0.012, 0.02, 0.005, 0.005, 0.005, 0.010, 0.010, 0.02,
     1      0.020, 0.02, 0.020, 0.010, 0.010  /
C
      DATA DECOMHI
     1    / 0.013, 0.02, 0.010, 0.010, 0.010, 0.015, 0.015, 0.03,
     1      0.030, 0.03, 0.020, 0.015, 0.030 /
C
C ************************************************************************
C                     PLANT OR DEVICE LIFETIMES
C     50-STATE PAPER 'COST OF DELIVERED ELECTRICITY' TAB COLUMNS U AND V
C ************************************************************************
C HYDRO      = 50-60 YEARS
C GEOTHERMAL = 30-40 YEARS
C ALL ELSE   = 25-35 YEARS
C
C YEARLIFEL = LIFETIME (YEARS) OF WWS DEVICES THAT GIVES LO COST
C YEARLIFEH = LIFETIME (YEARS) OF WWS DEVICES THAT GIVES HI COST
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C             HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C
      DATA YEARLIFEL
     1    /35., 35., 47., 49., 52., 50., 50., 50.,
     1     100., 50., 50., 40., 50. /
C
      DATA YEARLIFEH
     1    /25., 25., 41., 43., 45., 40., 40., 40.,
     1     70., 40., 40., 30., 40. /
C
C FRACLOAD = APPROXIMATE FRACTION OF TOTAL LOAD MET BY ENERGY TECHNOLOGY
C            ONWIND OFFWIND RESPV  COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO   TIDAL  WAVE  SOLTHERM GEOHEAT
C            FROM 50-STATE 50-state-WWS.xlsx 'End-use share by WWS technology' TAB
C            **** THESE DATA APPLY ONLY WHEN IFCONUS=1 (48-STATES) ***
C            FOR 145 COUNTRIES, FRACLOAD IS CALCULATED FROM LOAD DATA READ
C            LATER IN PROGRAM.
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER
C FOR IFCONUS=0, THESE VALUES ARE CALCULATED HEREIN
C
      DATA FRACLOAD
```

```
     1   /0.3092, 0.1908, 0.0398, 0.0324, 0.3073, 0.0730, 0.00, 0.0125,
     1    0.0301, 0.0014, 0.0037, 0.0000, 0.0000 /
C
C ***************************************************************************
C                    INSTALLED POWER DENSITY (KM2/MW)
C ***************************************************************************
C PDENINST = INSTALLED POWER DENSITY (KM2/MW) OF ENERGY DEVICES
C            FROM 145-COUNTRY SPREADSHEET 'Country and technology list'
C            CELLS K4..N15. FOR WIND AND WAVE, THESE NUMBERS ARE SPACING
C            DENSITIES. FOR EVERYTHING ELSE, THEY ARE FOOTPRINTS.
C            WIND VALUES FROM ENEVOLDSEN AND JACOBSON (ENERGY FOR
C            SUSTAINABLE DEVELOPMENT, 60, 40-51, 2021)
C
C            ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEOELEC
C            HYDRO  TIDAL   WAVE  SOLTHERM GEOHEAT
C
      DATA PDENINST
C NEW-19.8 MW/KM2 ONSHORE WIND; 7.2 MW/KM2 OFFSHORE WIND
     1   / 0.0505,0.139,0.00523,0.00523,0.01222,0.02935,0.02935,0.00329,
     1     0.50238, 0.004, 0.033, 0.00143, 0.00329 /
C
C ***************************************************************************
C           DEFAULT NUMBER OF OPERATION JOBS PER MW-NAMEPLATE FOR EACH TECH
C ***************************************************************************
C DEFOPJOB = DEFAULT NUMBER OPERATION JOBS PER MW-NAMEPLATE FOR EACH TECH
C              FOR TRANSMISSION, IT IS JOBS/KM
C              THESE ARE LONG-TERM, FULL-TIME JOBS
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C              (NOT NEEDED FOR TRANSMISSION HERE)
C
      DATA DEFOPJOB
     1   / 0.37, 0.63, 0.57, 0.46, 0.30, 0.61, 0.32,
     1     0.16, 0.85, 0.86, 0.85, 0.46, 0.00, 0.00 /
C
C ***************************************************************************
C              NUMBER OF CONSTRUCTION & OPERATION JOBS FOR STORAGE
C                  RAM ET AL. (2019) JOB CREATION DURING THE GLOBAL
C        ENERGY TRANISITION TOWARDS 100% RENEWABLE POWER SYSTEM BY 2050
C                TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE
C ***************************************************************************
C             MANUFACTURING  CONSTRUCTION  DECOMISSIONING  TOALCONST    O&M
C             (JOB-YRS/MW)   (JOB-YRS/MW)   (JOB-YRS/MW) (JOB-YRS/MW) (JOBS/MW)
C PHS             7.0          14.8            4.44        26.24         0.4
C BATTERIES      16.9          10.8            0.8         28.5          0.4
C H2             1.86           2.6            0.21         4.67         0.28
C
C ASSUME NUMBER OF BATTERY JOBS/MW DECLINE BY FACTOR DUE TO
C AUTOMATION & MORE EFFICIENY, LARGER BATTERIES
C ASSUME HEAT PUMP JOB RATES SAME AS CW-STES/HW-STES/UTES JOB RATES
C
C STORCJOB = CONSTRUC+MANUFAC+DECOMISS JOBS STORAGE (JOB-YRS/MW)
C            FOR STORAGE, PER MW PEAK DISCHARGE RATE
C            FOR H2, PER MW NEEDED FOR ELECTROLYSIS AND COMPRESSION
C STOROJOB = OPERATION AND MAINTENANCE (O&M) JOBS STORAGE (JOBS/MW)
C            FOR STORAGE, PER MW PEAK DISCHARGE RATE
C            FOR H2, PER MW NEEDED FOR ELECTROLYSIS AND COMPRESSION
C             1= PHS; 2=PCM-CSP; 3=BATTERIES; 4=CW-STES; 5=PCM-ICE;
C             6=HW-STES; 7=UTES; 8=HYDROGEN; 9=HEAT PUMPS;
C             10=FIREBRICKS
C
      DATA STORCJOB
     1  /25.0, 20.0, 3.0, 5.0, 5.0, 5.0, 5.0, 4.0, 5.0, 0.6/
C
      DATA STOROJOB
     1  /0.3,   0.3, 0.2, 0.3, 0.3, 0.3, 0.3, 0.3, 0.3, 0.2/
C
C ***************************************************************************
C                              DISCOUNT RATE
C ***************************************************************************
C DISCOUNTL = LOW SOCIAL DISCOUNT RATE FOR INTERGENERATIONAL PROJECT
C             (SEE JACOBSON ET AL. JOULE, 2017)
C DISCOUNTM = MEAN DISCOUNT RATE (FRACTION ON 1 BILLION LOAN)
C DISCOUNTH = HI DISCOUNT RATE (FRACTION ON 1 BILLION LOAN)
```

```
C
      DISCOUNTL = 0.01
      DISCOUNTH = 0.03
      DISCOUNTM = 0.5 * (DISCOUNTL + DISCOUNTH)
C
C *************************************************************************
C                          COSTS OF STORAGE
C *************************************************************************
C COSTSTORL = LO LIFECYCLE COST OF STORAGE ($/KWH-TH OR $/KWH-ELEC)
C COSTSTORM = MEAN LIFECYCLE COST OF STORAGE ($/KWH-TH OR $/KWH-ELEC)
C COSTSTORH = HI LIFECYCLE COST OF STORAGE ($/KWH-TH OR $/KWH-ELEC)
C             1=PHS-PUMPED HYDRO ($/KWH-ELEC)
C               (14, POONPUN&JEWELL IEEE EN CONVER 23,529,2008)
C             2=COLD-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE (CW-STES)
C               0.1-10 EUROS/KWH = $0.13-12.9/KWH-TH - IRENA
C               AND SARBU & SEBARCHIEVICI SUSTAINABILITY 10, 191 (2018)
C               MULTIPLY LATER BY CPERFORM TO GET $/KWH-ELEC
C             3=PCM-CSP (COST OF PHASE-CHANGE MATERIAL)
C               PHASE CHANGE MATERIALS COSTS ARE 15.3 (10-20) $/KWH-TH
C               NITHYANANDAM ENERGY 64, 793 (2014)
C               20.5-22.2 $/KWH FOR 6-8 HR LHTES STORAGE FROM TABLE 13 OF
C               XU ET AL. APPLIED ENERGY 160, 286-307 (2015)
C             4=PCM-CSP (COST OF EXTRA MIRRORS)
C
C                        DOE       LAZARD
C DOE: 0 HRS STORAGE -- 25% CF
C      6 HRS         -- 42%
C      10 HRS                        52% ($7000/KW)
C      12 HRS        -- 59%
C      14 HRS        -- 66%
C      18 HRS        -- 80%   =     80% ($9800/KW) USE $8700/KW TO ACCT FOR PCM
C                                       $1700/8=$212/KW-TURBINE-HR-STORAGE
C                                       RATIO OF KWH-STORAGE TO KWH-TURBINE
C                                       IS CF W/18 HRS TO CF W/0 HRS
C                                       = 80/25 = 3.2
C                                       --> $212/3.2 = $66/  KWH-STORAGE 2013
C                                       -->          = $45.6/KWH-STORAGE 2050
C                                       -->          = $55.8/KWH-STORAGE MEAN
C                                       (INCLUDES PCM AND EXTRA MIRRORS)
C
C             OF THIS TOTAL $15.3 (10-20)/KWH-TH IS DUE TO PCM SO SUBTRACT IT
C             OFF GIVING $40.5 (35.6-46)/KWH-TH FOR MIRRORS
C
C             5=PCM-ICE (ICE FROZEN DURING THE NIGHT; MELTED DURING THE DAY)
C               10-50 EUROS/KWH-TH = $12.9-64.5/KWH - IRENA
C               MULTIPLY LATER BY CPERFORM TO GET $/KWH-ELEC
C             6=HOT-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE (HW-STES)
C               USE SAME EFFICIENCES AS CW-STES ($/KWH-TH)
C               MULTIPLY LATER BY CPERFORM TO GET $/KWH-ELEC
C             7=LITHIUM-ION BATTERIES ($/KWH-ELEC)
C               https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/
C               https://electrek.co/2023/11/20/electric-car-battery-prices-are-going-back-down-faster/
C             8=FIREBRICK BATTERIES (1/10TH COST/kWH-STORAGE AS LI)(#/KWH-TH)
C               https://www.youtube.com/embed/X6Wgd4v_yW8?autoplay=1
C
      DATA COSTSTORL /12.,  0.1,  15., 35.6, 10.,  0.1,  30., 3. /
      DATA COSTSTORM /14.,  3.0,  20., 40.5, 25.,  3.0,  60., 6. /
      DATA COSTSTORH /16., 10.0,  23., 46.0, 40., 10.0,  90., 9. /
C
C COSTUTESL = LO LIFECYCLE COST OF UTES STORAGE ($/KWH-TH)
C             MULTIPLIED LATER BY CPERFORM SO THAT COST IS $/KWH-ELEC
C             SINCE ALL ENERGY GOING INTO STORAGE CONVERTED TO
C             ELECTRICITY
C           = 0.055-0.071 EUROS/KWH = 0.066-0.085 $/KWH
C           = (FROM GAINE, 2010)
C             http://arrow.dit.ie/cgi/viewcontent.cgi?article
C             =1007&context=dubencon2
C COSTUTESM = MEAN LIFECYCLE COST OF UTES STORAGE ($/KWH-TH)
C             WATER PIT STORAGE DRONNINGLUND 5.4 GWH-TH
C             INVESTMENT COST $0.47/kWH-TH (JACOBSON 2020 CUP P. 65)
C             WATER PIT STORAGE MARSTAL 6 GWH-TH
C             INVESTMENT COST $0.48/kWH-TH (JACOBSON 2020 CUP P. 65)
C COSTUTESH = HI LIFECYCLE COST OF UTES STORAGE ($/KWH-TH)
C           = $3.13/kWH = AVG OF $1.71, 4.55/kWh: 1.5-3 KBTU/FT^3;
C             $1.5-2/FT^3; 3.41214 KBTU/KWH
```

```
C             http://www.igshpa.okstate.edu/membership/members_only/proceedings/
C             2011/100611-1030-B-Christopher%20Fox%20-%20Rehau%20-%20
C             Underground%20Thermal%20Energy%20Storage.pdf
C
      COSTUTESL = 0.1
      COSTUTESM = 0.4
      COSTUTESH = 1.0
C
C GWPERMW  = 0.001    GIGAWATTS (GW) PER MEGAWATT (MW)
C TWPERMW  = 0.000001 TERAWATTS (TW) PER MEGAWATT (MW)
C TWPERGW  = 0.001    TERAWATTS (TW) PER GIGAWATT (GW)
C GWPTW    = 1000.    GIGAWATTS (GW) PER TERAWATT (TW)
C AKWPTW   = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KWH PER TWH
C AKWPGW   = 1.0E+06  KILOWATTS (KW) PER GIGAWATT (GW)
C TRILPDOL = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C CENTPDOL = 100.     CENTS PER DOLLAR
C PCT      = 100.     CONVERTS FRACTION TO PERCENT
C TRILFACT = CENTS-TW/(TRIL$-KW) = 100 CENTS/$/($TRIL/$ * 1.0E+09 KWH/TWH)
C SMAL30   = 1.0E-30 = SMALL NUMBER TO PREVENT DIVIDE BY ZERO
C AVHRSPYR = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C
      GWPERMW  = 0.001
      TWPERMW  = 0.000001
      TWPERGW  = 0.001
      GWPTW    = 1000.
      AKWPTW   = 1.0E+09
      AKWPGW   = 1.0E+06
      TRILPDOL = 1.0E-12
      CENTPDOL = 100.
      PCT      = 100.
      TRILFACT = CENTPDOL / (TRILPDOL * AKWPTW)
      SMAL30   = 1.0E-30
      AVHRSPYR = 8760.
C
C HRSPDAY = NUMBER OF HOURS PER DAY (24)
C
      HRSPDAY = FLOAT(MXHPDAY)
C
C DTHRES    = 30  = HIGH-RESOLUTION TIME STEP (S)
C NTSPERHR  = 120 = NUMBER OF 30-SECOND TIMES STEPS PER HR
C
      DTHRES   = 30.
      NTSPERHR = 120
C
C ***************************************************************************
C                      INPUT AND OUTPUT FILE NUMBERS
C ***************************************************************************
C
      IOUT = 6
      KOUT = 7
      IMON = 11
      IHOU = 12
C
      KHTE = 14
      KLOD = 15
      KWWS = 16
      KWW2 = 17
      KDAT = 19
      KHDD = 20
C
C MAKE SURE THERE ARE NO OTHER FILE NUMBERS LARGER THAN KWW3 SINCE
C KWW3 + NUMGRIDS - 1 FILE NUMBERS WILL BE OPENED USING KWW3
C
      KWW3 = 30
C
C PATHHOME = DIRECTORY WHERE POWERWORLD.F AND MOST INPUT/OUTPUT LIE
C PATHTEMP = DIRECTORY WHERE wwssupworld.dat READ FROM WHEN IFREWRITE=1,2
C PATHTEM1 = DIRECTORY TO WRITE wwssupreform.dat TO WHEN IFREWRITE=2
C            (READS wwssupworld.dat FROM PATHTEMP)
C PATHLOAD = DIRECTORY WHERE HOURLY LOAD DATA ARE LOCATED
C
      PATHHOME = '/scratch/jacobson/loadmatch/'
      PATHTEMP = '/scratch/jacobson/loadmatch/'
      PATHTEM1 = '/scratch/jacobson/loadmatch/'
      PATHLOAD = '/scratch/jacobson/loadmatch/LOADHOURLY/'
```

```
C
C ***************************************************************************
C                  PARAMETERS THAT MODEL USERS CHANGE
C ***************************************************************************
C IFCONUS = 1: SOLVE GRID INTEGRATION OVER 48 CONTIGUOUS UNITED STATES (CONUS)
C              AGGREGATE CONUS DATA ARE SPECIFIED WITHIN THIS PROGRAM
C              OBTAINED FROM 50-STATE 50-state-WWS.xlsx FILE
C          = 0: SOLVE GRID INTEGRATION OVER REGION OF THE WORLD GRIDUSE,
C              WHERE COUNTRIES TREATED IN EACH GRID REGION AND THEIR
C              CHARACTERISTICS ARE DEFINED IN countrystats.dat, WHICH IS
C              OBTAINED FROM 'Table for GATOR-GCMOM' TAB IN Allcountries.xlsx
C
      IFCONUS = 0
C
C IFSTATES  = 1: THEN RUN SIMS WITH INDIVIDUAL OR GROUPS OF US STATES+DC
C                SIMULATIONS USE GATOR-GCMOM SUPPLY DATA STARTING 12
C                12 GMT JAN1 2050 (OFFSET=12.) AND IFHRLOAD=0
C
      IFSTATES = 0
C     IFSTATES = 1
C
C IFCANARY  = 1: THEN RUN SIMULATIONS WITH THE CANARY ISLANDS. THESE
C                SIMULATIONS USE DATA STARTING 0 GMT JAN 1 RATHER THAN
C                12 GMT JAN 1 (OFFSET=0). ALSO USES IFHRLOAD=1
C           = 0: SIMULATIONS USING GATOR-GCMOM SUPPLY DATA STARTING 12
C                12 GMT JAN1 (OFFSET=12.). ALSO IFHRLOAD=0
C
      IFCANARY = 0
C     IFCANARY = 1
C
      IF (IFCONUS.EQ.1.AND.IFSTATES.EQ.1.AND.IFCANARY.EQ.1) THEN
       WRITE(IOUT,*)'CAN ONLY HAVE ONE OR NONE OF IFCONUS,IFSTATES ',
     1              'IFCANARY ON ', IFCONUS, IFSTATES, IFCANARY
       STOP
      ENDIF
C
C IFHEATBAT = 1: USE HIGH-TEMP FIREBRICKS FOR HEAT STORAGE FOR INDUSTRY
C                FLEXIBLE & INFLEXIBLE HI-TEMP HEAT LOADS
C           = 0: DO NOT USE HEAT BATTERIES.
C
      IFHEATBAT = 1
C     IFHEATBAT = 0
C
C IMERGH2 = 0: DO NOT INCLUDE ANY H2 FOR GRID ELECTRICITY
C         = 1: MERGE ELECTROLYZERS, COMPRESSORS, & STORAGE FOR
C              GRID AND NON-GRID H2.
C         = 2: KEEP ELECTROLYZERS, COMPRESSORS, & STORAGE
C              SEPARATE FOR GRID VERSUS NON-GRID H2
C         = 3: SAME AS IMERGH2=1, BUT WITH NO BATTERIES (BATDISCH=0)
C
C     IMERGH2 = 0
      IMERGH2 = 1
C     IMERGH2 = 2
C     IMERGH2 = 3
C
C THIS = 0, EXCEPT WHEN IMERGH2=2. THERE, IT IS SET LATER ON.
C
      STORHHFC = 0.
C
C VEHPROF = PERCENT OF DAILY VEHICLE CHARGING OCCURRING EACH HOUR OF
C           DAY. HOUR 1 = 0-1AM LOCAL TIME. VALUES MUST ADD TO 100.
C VEHRAT  = RATIO OF CHARGING IN GIVEN HOUR TO DAILY-AVG CHARGING
C           VALUES MUST ADD TO 24 OVER 24 HOURS IN A DAY
C AVPCT   = AVERAGE PERCENT OF CHARGING PER HOUR
C
      SUMVPR      = 0.
      SUMVP2      = 0.
      AVPCT       = 100. / MXHPDAY
      DO J        = 1, MXHPDAY
       SUMVPR     = SUMVPR + VEHPROF(J)
       VEHRAT(J)  = VEHPROF(J) / AVPCT
       SUMVP2     = SUMVP2 + VEHRAT(J)
      ENDDO
C
      IF (ABS(SUMVPR-100.).GT.1E-12.OR.ABS(SUMVP2-24.).GT.1E-12) THEN
```

```
       WRITE(IOUT,*)'SUMVPR.NE.100.OR.SUMVP2.NE.24 ',SUMVPR,SUMVP2
       STOP
      ENDIF
C
C IFGATHEAT = 1: READ IN AND USE BUILDING HEATING AND COOLING ENERGY NEEDED EACH
C                TIME STEP FOR EACH COUNTRY IN wwssupworld.dat (wwssupply.xxx)
C                THIS IS USED TO SHAPE TIME-DEPENDENT HEATING/COOLING PROFILES
C                --> THIS AVOIDS USING DATA FROM heatcooldd.dat TO DO THIS
C           = 2: READ IN BUT DO NOT USE BUILDING HEATING AND COOLING ENERGY
C                INSTEAD USE HEATING-DEGREE AND COOLING-DEGREE DAY DATA
C                FROM heatcooldd.dat
C           = 0: DO NOT READ IN OR USE HEATING OR COOLING ENERGY
C                THIS IS USED ONLY WHEN PREVIOUS FORMAT W/O HEAT IS USED
C OFFSET    = TIME (HOURS) ADDED TO TIMWWS SO THAT IT IS CONSISTENT WITH TIMLOAD
C             SINCE SIMULATION FOR TIMWWS STARTED AT 12 GMT FIRST DAY, WHICH
C            ORIGINALLY CORRESPONDS TO TIMWWS=0. OFFSET MAKES THIS TIMWWS=12
C IFHRLOAD  = 1: HI-RESOLUTION (30-SECOND) LOAD DATA
C           = 0: 1-HOUR RESOLUTION LOAD DATA
C
      IF (IFCANARY.EQ.1) THEN
       IFGATHEAT = 0
       OFFSET    = 0.
       IFHRLOAD  = 1
      ELSE
       IFGATHEAT = 1
       OFFSET    = 12.
       IFHRLOAD  = 0
      ENDIF
C
C GRIDUSE = NAME OF GRID REGION SIMULATED FOR PRESENT SIMULATION (SET HERE)
C           GRIDUSE IS NOT USED WHEN IFCONUS = 1
C
C ***************************************************************************
C             29 GRID REGIONS USED IN 149-COUNTRY ROADMAP PAPERS
C ***************************************************************************
C
      IF (IFCONUS.EQ.0.AND.IFSTATES.EQ.0.AND.IFCANARY.EQ.0) THEN
C      GRIDUSE = 'AFRICA-EAST'
C      GRIDUSE = 'AFRICA-NORTH'
C      GRIDUSE = 'AFRICA-SOUTH'
C      GRIDUSE = 'AFRICA-WEST'
C      GRIDUSE = 'AUSTRALIA'
C      GRIDUSE = 'CANADA'
C      GRIDUSE = 'CENTRAL-AMERIC'
C      GRIDUSE = 'CENTRAL-ASIA'
C      GRIDUSE = 'CHINA'
C      GRIDUSE = 'CUBA'
C      GRIDUSE = 'EUROPE'
C      GRIDUSE = 'HAITI'
C      GRIDUSE = 'ICELAND'
C      GRIDUSE = 'INDIA'
C      GRIDUSE = 'ISRAEL'
C      GRIDUSE = 'JAMAICA'
C      GRIDUSE = 'JAPAN'
C      GRIDUSE = 'MADAGASCAR'
C      GRIDUSE = 'MAURITIUS'
C      GRIDUSE = 'MIDEAST'
C      GRIDUSE = 'NEW-ZEALAND'
C      GRIDUSE = 'PHILIPPINES'
C      GRIDUSE = 'RUSSIA'
C      GRIDUSE = 'SOUTHAM-NW'
C      GRIDUSE = 'SOUTHAM-SE'
C      GRIDUSE = 'SOUTHEAST-ASIA'
C      GRIDUSE = 'SOUTH-KOREA'
C      GRIDUSE = 'TAIWAN'
       GRIDUSE = 'UNITED-STATES'
C
C ***************************************************************************
C           24 GRID REGIONS USED IN 143- AND 145-COUNTRY ROADMAP PAPERS
C ***************************************************************************
C
C      GRIDUSE = 'AFRICA'
C      GRIDUSE = 'AUSTRALIA'
C      GRIDUSE = 'CANADA'
C      GRIDUSE = 'CENTRAL-AMERIC'
```

```
C      GRIDUSE = 'CENTRAL-ASIA'
C      GRIDUSE = 'CHINA'
C      GRIDUSE = 'CUBA'
C      GRIDUSE = 'EUROPE'
C      GRIDUSE = 'HAITI'
C      GRIDUSE = 'ICELAND'
C      GRIDUSE = 'INDIA'
C      GRIDUSE = 'ISRAEL'
C      GRIDUSE = 'JAMAICA'
C      GRIDUSE = 'JAPAN'
C      GRIDUSE = 'MAURITIUS'
C      GRIDUSE = 'MIDEAST'
C      GRIDUSE = 'NEW-ZEALAND'
C      GRIDUSE = 'PHILIPPINES'
C      GRIDUSE = 'RUSSIA'
C      GRIDUSE = 'SOUTH-AMERICA'
C      GRIDUSE = 'SOUTHEAST-ASIA'
C      GRIDUSE = 'SOUTH-KOREA'
C      GRIDUSE = 'TAIWAN'
C      GRIDUSE = 'UNITED-STATES'
C
C ***************************************************************************
C THESE GRIDS ARE FOR TESTING EFFECT OF COMBINING COUNTRIES ON GRID STABILITY
C ***************************************************************************
C NORDEN         = NORWAY + DENMARK
C NORDENSWEGER   = NORWAY + DENMARK + SWEDEN + GERMANY
C NODESWGENEBELU = NOR+DEN+SWE+GER+NET+BEL+LUX
C SWIGER         = SWITZERLAND + GERMANY
C SWIFRA         = SWITZERLAND + FRANCE
C SWIITA         = SWITZERLAND + ITALY
C NWEUROPE       = NOR+DEN+SWE+GER+NET+BEL+LUX+FRA+SWI
C SPAPORGIB      = SPAIN + PORTUGAL + GIBRALTAR
C WESTEUROPE     = NOR+DEN+SWE+GER+NET+BEL+LUX+FRA+SWI+ITA+SPA+POR+GIB
C                  DOESN'T INCLUDE UK
C
C INDIVIDUAL COUNTRIES
C
C      GRIDUSE     = 'BELGIUM'
C      GRIDUSE     = 'DENMARK'
C      GRIDUSE     = 'FRANCE'
C      GRIDUSE     = 'GERMANY'
C      GRIDUSE     = 'GIBRALTAR'
C      GRIDUSE     = 'ITALY'
C      GRIDUSE     = 'LUXEMBOURG'
C      GRIDUSE     = 'NETHERLANDS'
C      GRIDUSE     = 'NORWAY'
C      GRIDUSE     = 'PORTUGAL'
C      GRIDUSE     = 'SPAIN'
C      GRIDUSE     = 'SWEDEN'
C      GRIDUSE     = 'SWITZERLAND'
C      GRIDUSE     = 'UNITED-KINGDOM'
C
C COMBINATIONS OF COUNTRIES
C
C      GRIDUSE     = 'NORDEN'
C      GRIDUSE     = 'NORDENSWEGER'
C      GRIDUSE     = 'NODESWGENEBELU'
C      GRIDUSE     = 'SWIFRA'
C      GRIDUSE     = 'SWIGER'
C      GRIDUSE     = 'NWEUROPE'
C      GRIDUSE     = 'SWIITA'
C      GRIDUSE     = 'SPAPORGIB'
C      GRIDUSE     = 'WESTEUROPE'
C
C ***************************************************************************
C      THESE GRIDS ARE FOR TESTING INDIVIDUAL AND COMBINED CANARY ISLANDS
C ***************************************************************************
C FOR THESE GRIDS, IFCANARY MUST = 1
C
      ELSEIF (IFCANARY.EQ.1) THEN
C      GRIDUSE     = 'GRAN-CANARIA'
C      GRIDUSE     = 'LANZAROTE-FV'
C      GRIDUSE     = 'TENERIFE'
C      GRIDUSE     = 'LA-PALMA'
C      GRIDUSE     = 'LA-GOMERA'
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C      GRIDUSE     = 'EL-HIERRO'
C      GRIDUSE     = 'GRANCAN-LZFT'
C      GRIDUSE     = 'TENER-LAGOM'
       GRIDUSE     = 'LANZ-FV-CSP'
C      GRIDUSE     = 'ALL-CANARY'
C
C ***************************************************************************
C      THESE GRID REGIONS ARE FOR INDIVIDUAL OR GROUPS OF 50 US STATES + DC
C ***************************************************************************
C             NORTH AMERICAN RELIABILITY CORPORATION (NERC) REGIONS
C ***************************************************************************
C WECC  = WESTERN ELECTRICITY COORDINATING COUNCIL
C         Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon,
C         Utah, Washington State, Wyoming
C MRO   = MIDWEST RELIABILITY ORGANIZATION
C         Iowa, Kansas, Minnesota, Nebraska, North Dakota, Oklahoma, South Dakota,
C         Wisconsin
C TRE   = TEXAS RELIABILITY ENTITY
C         Texas
C RFC   = RELIABILITY FIRST CORPORATION
C         Delaware, Indiana, Maryland, Michigan, New Jersey, Ohio, Pennsylvania,
C         Washington D.C., West Virginia
C SERC  = SOUTHEASTERN ELECTRIC RELIABILITY COUNCIL
C         Alabama, Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi,
C         Missouri, North Carolina, South Carolina, Tennessee, Virginia
C NPCC  = NORTHEAST POWER COORDINATING COUNCIL
C         Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont
C ASCC  = ALASKA SYSTEM COORDINATING COUNCIL
C         Alaska
C HICC  = HAWAIIAN ISLANDS COORDINATING COUNCIL
C         Hawaii
C CALI  = CALIFORNIA ALONE
C FLA   = FLORIDA ALONE
C NEWY  = NEW YORK STATE ALONE
C USCON = 48 US STATES + DC
C TXMRO = TEXAS + MRO (IA,KS,MN,NE,ND,OK,SD,WI)
C
      ELSEIF (IFSTATES.EQ.1) THEN
C      GRIDUSE     = 'WECC'
C      GRIDUSE     = 'MRO'
C      GRIDUSE     = 'TRE'
C      GRIDUSE     = 'RFC'
C      GRIDUSE     = 'SERC'
C      GRIDUSE     = 'NPCC'
C      GRIDUSE     = 'ASCC'
C      GRIDUSE     = 'HICC'
       GRIDUSE     = 'CALI'
C      GRIDUSE     = 'FLA'
C      GRIDUSE     = 'NEWY'
C      GRIDUSE     = 'TXMRO'
C      GRIDUSE     = 'USCON'
C
C ***************************************************************************
C    THIS GRID IS THE CONTINENTAL US TREATED AS ONE, BASED ON STATE ROADMAPS
C ***************************************************************************
C
      ELSE
       GRIDUSE = 'CONUS'
      ENDIF
C
      WRITE(IOUT,111) GRIDUSE
 111  FORMAT('DOMAIN: ',A14,' POWERWORLD.F LOADMATCH GRID INTEGRATION ',
     1       'MODEL'/)
C
C ***************************************************************************
C WHEN HAVE A NEW wwssupply.XXXX FILE, FIRST GO THROUGH IFREWRITE=1,
C THEN IFREWRITE=2, THEN IFREWRITE=3
C ***************************************************************************
C IFREWRITE = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                AND ELIMINATING AVERAGE VALUES (KEEPING INSTANT VALUES ONLY)
C                WHEN THIS IS COMPLETE, USE KWW2 FILE AS INPUT FOR IFREWRITE=2
C                APPLIES WHEN IFCONUS=1 OR 0
C                AFTER FINISHINING IFREWRITE=1, CAN ERASE KWWS (wwssupworld.dat)
C
```

```
C                --> IF WANT TO INTERPOLATE SOLAR OR ADD TILT FACTORS,
C                RUN SOLARTILT/tilt.f, BUT ADJUST SOLAR FOR TILTING ONLY
C                FOR OLD FILES SINCE GATOR-GCMOM NOW INCLUDES TILTING.
C                APPLIES ONLY TO IFCONUS=0
C                --> MOVE OUTPUT FILE FROM tilt.f (wwstilt.dat) to
C                wwssupreform.dat
C           = 2: READS KWW2 (wwssupreform.dat),
C                SUMS VALUES EACH TIME STEP AMONG ALL COUNTRIES IN GRID
C                REGION GRIDUSE, REWRITES SUMMED VALUES TO A SMALLER FILE
C                KWW3 (wwssupworld.REGION) (FOR EACH REGION
C                ALSO CALCULATES CAPACITY FACTOR (CF) OF ONSHORE, OFFSHORE WIND;
C                ROOFTOP & UTILITY PV AND CSP FROM GATOR-GCMOM SIMULATIONS
C                BY COUNTRY.
C           = 3: APPLIES ONLY WHEN IFCONUS=0:
C                READS DATA FROM FILE wwssupworld.REGION RATHER THAN
C                wwssupworld.dat FOR ONE GRID REGION.
C                FILE KWW3 CONTAINS ONLY ONE LINE OF DATA FOR EACH TIME STEP,
C                WHICH ARE DATA SUMMED OVER ALL COUNTRIES IN GRID REGION GRIDUSE
C           = 0: READ AND PROCESS FILE KWWS
C                APPLIES WHEN IFCONUS=1 OR 0
C                (WHEN IFCONUS=0, READS ALL-COUNTRY DATA)
C
C WHEN IFCONUS=0, RUN IN SEQUENCE IFREWRITE=1,2,3
C      IFCONUS=1, RUN IN SEQUENCE IFREWRITE=1,0
C      MAY RUN SOLARTILT/tilt.f BEFORE RUNNING WITH IFREWRITE=2
C
      IF (IFCONUS.EQ.1) THEN
       IFREWRITE = 0
      ELSE
C      IFREWRITE = 1
C      IFREWRITE = 2
       IFREWRITE = 3
      ENDIF
C
C INITYEAR = INITIAL YEAR OF SIMULATIONS
C
      INITYEAR  = 2050
C
C ISUPYEAR = 1: START SIMULATION WITH FIRST YEAR OF MODEL OUTPUT WIND/SOLAR
C                FIELDS IN KWWS
C          = 2: START SIMULATION SECOND YEAR OF MODEL OUTPUT WIND/SOLAR
C                FIELDS IN KWWS
C          = 3: START SIMULATION THIRD YEAR OF MODEL OUTPUT WIND/SOLAR
C                FIELDS IN KWWS
C
      ISUPYEAR = 1
C     ISUPYEAR = 2
C     ISUPYEAR = 3
C     ISUPYEAR = 4
C     ISUPYEAR = 5
C     ISUPYEAR = 6
C
      ISUPYEAR = MIN0(ISUPYEAR,NYEARS)
C
C ***************************************************************************
C                          SPECIFY MAIN SCENARIOS
C ***************************************************************************
C IFHPTURB = 1: ADD HYDROPOWER TURBINES WITHOUT INCREASING ANNUAL AVERAGE
C                HYDRO OUTPUT TO SOME REGIONS (HPTURBRAT>1). HPTURBRAT
C                MAY = 1. IN THESE SCENARIOS, NO STATIONARY BATTERY STORAGE
C          = 0: HPTURBRAT MUST = 1. STORAGE WITH BATTERIES, CSP, ETC.
C
      IFHPTURB = 0
C     IFHPTURB = 1
C
C CPERFORM = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C            (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C          = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
C          = 1 FOR ELECTRIC RESISTANCE HEATING
C          = 3.2-4.5 FOR AIR SOURCE HEAT PUMPS
C          = 4.2-5.2 FOR GROUND SOURCE HEAT PUMPS
C          https://en.wikipedia.org/wiki/Heat_pump
C
C SINCE CURRENT VERSION OF countrystats.dat ALREADY ASSUMES HEAT PUMPS
C FOR ALL HEATING/COOLING, NO NEED TO ADJUST LOAD
```

```
C
      CPERFORM = 4.0
C
C CPERF1 = CPERFORM = COEF OF PERFORMANCE OF HEAT PUMPS WHEN NEW SOLAR+GEOTHERMAL
C          HEAT ASSUMED. NEW SOLAR+GEOTHERMAL HEAT ARE ASSUMED TO BE
C          CONVERTED TO ELECTRICITY POWERING HEAT PUMPS
C          (IN THIS CASE, CAPACITY FACTORS FOR SOLAR+GEOTHERMAL HEAT WILL
C           RESULT IN ENERGY OUTPUTS DIFFERENT FROM THOSE FROM ENERGY BUDGET
C           SINCE CF WILL BE BASED ON HEAT AND BUDGET WILL BE BASED ON ELECTRICITY.
C        = 1 WHEN ONLY EXISTING SOLAR+GEOTHERMAL HEAT ASSUMED SINCE EXISTING
C          SOLAR+GEOTHERMAL HEAT IS TREATED AS DIRECT HEAT IN IEA DATABASE
C          SO NO NEED TO CONVERT TO EQUIVALENT ELECTRICITY
C          (ALSO ENERGY OUTPUT FROM CF WILL BE CONSISTENT WITH FROM
C           BUDGET)
C
C USE CPERF1 =1 FOR 145-COUNTRY ROADMAPS SINCE NO NEW SOLAR OR GEOTHERMAL
C               HEAT IS ADDED. ONLY EXISTING SOLAR+GEOTHERMAL HEAT.
C
C     CPERF1   = CPERFORM
      CPERF1   = 1.0
C
C FMORTBAU  = FRACTION OF ALL AIR POLLUTION DEATHS DUE TO BAU ENERGY
C           = 0.9 FROM 145-COUNTRY SPREADSHEET WHERE AP COSTS CALCULATED
C
      FMORTBAU = 0.9
C
C DEGXLON = DEGREES LONGITUDE (+ IS EAST) IN MIDDEL OF REGION
C           DEFAULT IS ZERO
C
C     DEGXLON  = 0.
C
C DAMCAPRAT = RATIO OF HYDRO DAM ENERGY STORAGE CAPACITY TO ANNUAL
C             HYDRO ENERGY OUTPUT FOR REGION (TWH/TWH/Y = UNITS OF YEARS)
C             THIS IS THE FRACTION OF A YEAR THAT A HYDRO PLANT CAN
C             DISCHARGE AT ITS PEAK DISCHARGE RATE
C             BASED ON FIG. 4.8 OF IEA (2021) HYDROPOWER SPECIAL MARKET REPORT
C             https://iea.blob.core.windows.net/assets/4d2d4365-08c6-4171-9ea2
C             -8549fabd1c8d/HydropowerSpecialMarketReport_corr.pdf
C             PROVIDES ENERGY STORAGE CAPACITY (TWH) OF HYDRO RESERVOIRS
C             NOTE: THE CALCULATIONS BELOW ARE PERFORMED WITH ANNUAL
C             HYDRO OUTPUT (CURHYD, TWH/Y), WHICH IS DELIVERED HYDRO
C             AFTER T&D LOSSES. AS SUCH, DAMCAPRAT MUST BE MULTIPLIED BY
C             CURHYD (NOT TURBHYD) TO OBTAIN TOTAL DAM CAPACITY IN
C             COUNTRY.
C
C                             DAM CAPACITY   HYDRO OUTPUT              RATIO (YR)
C             NORTH AMERICA: 370 TWH        317.3+317.5=634.8  TWH/Y      0.583
C               CANADA+USA
C             CHINA:         250 TWH       1384.0             TWH/Y        0.181
C               CHINA REGION
C             LATIN AMERICA: 245 TWH        680.9+74.2+0.26+2.63+0.104
C                                                    =758.1 TWH/Y        0.323
C               SOUTH AMERICA+CENTRAL AMERICA
C             EUROPE:        215 TWH        660.2+8.7=668.9  TWH/Y        0.321
C               EUROPE+ICELAND
C             EURASIA:       130 TWH        202.8+91.4=294.2 TWH/Y        0.442
C               RUSSIA+CENTRAL ASIA
C             AFRICA:        125 TWH        117.2            TWH/Y        1.07
C               AFRICA
C             ASIA PACIFIC:  120 TWH         30.3+21.3+0.251+91.5+
C                                           +8.72+7.47+14.3+169+187.8
C                                           =530.6           TWH/Y        0.226
C               AUSTRALIA+NEW ZEALAND+MAURITIUS+JAPAN+TAIWAN+SKOREA+
C               PHILIPPINES+SOUTHEAST ASIA+INDIA
C             MIDDLE EAST:    15 TWH        178.9+0.0289=178.9 TWH/Y      0.0838
C               MIDDLE EAST+ISRAEL
C             WORLD TOTAL:  1470 TWH       4567              TWH/Y        0.322
C
C DCRNORTHAM = DAMCAPRAT FOR NORTH AMERICA
C              CANADA+US+CUBA+HAITI+JAMAICA
C DCRCHINA   = DAMCAPRAT FOR CHINA
C              CHINA REGION
C DCRLATAM   = DAMCAPRAT FOR LATIN AMERICA
C              SOUTH AMERICA+CENTRAL AMERICA
C DCREUROPE  = DAMCAPRAT FOR EUROPE
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C              EUROPE+ICELAND
C DCREURASIA = DAMCAPRAT FOR EURASIA
C              RUSSIA+CENTRAL ASIA
C DCRAFRICA  = DAMCAPRAT FOR AFRICA
C              AFRICA
C DCRASIAPAC = DAMCAPRAT FOR ASIA PACIFIC
C              AUSTRALIA+NEW ZEALAND+MAURITIUS+JAPAN+TAIWAN+SKOREA+
C              PHILIPPINES+SOUTHEAST ASIA+INDIA
C DCRMIDEAST = DAMCAPRAT FOR MIDDLE EAST
C              MIDDLE EAST+ISRAEL
C DCRWORLD   = DAMCAPRAT FOR WORLD ON AVERAGE
C
      DCRNORTHAM = 0.583
      DCRCHINA   = 0.181
      DCRLATAM   = 0.323
      DCREUROPE  = 0.321
      DCREURASIA = 0.442
      DCRAFRICA  = 1.07
      DCRASIAPAC = 0.226
      DCRMIDEAST = 0.0838
      DCRWORLD   = 0.322
C
C STORUGDYS = DAYS OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL OR WATER (UTES) (HRS)
C             DRAKE LANDING STORAGE SUPPLIES 100% OF WINTER AIR HEAT (90 DAYS)
C STORHHWAT = MAX NUMBER HOURS HOT-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE
C GRIDUSE   = NAME OF GRID REGION SIMULATED FOR PRESENT SIMULATION (SET HERE)
C GRIDLOAD  = NAME OF LOAD DATA COUNTRY OR REGION USED FOR GRIDUSE REGION.
C             GRIDLOAD = 'COUNTRY2030GW' -> DATA FROM loadreg.COUNTRY2030GW
C             GRIDLOAD = 'CONUS2016-19' -> DATA FROM loadreg.CONUS2016-19
C             GRIDLOAD = 'XXX' (WHERE XXX IS ANY COUNTRY NAME)
C             GRIDLOAD = 'CONUS' --> DATA FROM loadreg.CONUS
C             GRIDLOAD = GRIDUSE -> DATA FROM loadreg.XXX
C             IF GRIDLOAD = 'XXX' THEN HOURLY LOAD WILL BE SCALED TO HOURLY
C              FROM COUNTRY'S DATA. IF GRIDLOAD='CONUS' THEN IT WILL BE SCALED
C              FROM CONUS DATA.
C             IF GRIDLOAD = GRIDUSE OR GRIDLOAD = 'COUNTRY2030GW' THEN
C              SUM LOADS FOR GRID REGION OVER ALL COUNTRIES IN REGION
C              FOR WHICH FILES AVAILABLE. FOR EXAMPLE, IF GRIDLOAD='EUROPE',
C              SUM OVER ALL COUNTRIES IN EUROPE FOR WHICH DATA ARE AVAILABLE. IF
C              DATA ARE NOT AVAILABLE FOR A COUNTRY IN THE REGION, THAT IS OKAY,
C              SINCE DATA FOR THE OTHER COUNTRIES ARE STILL SUMMED, AND FINAL
C              LOAD IS SCALED BY TAKING THE PRODUCT OF 2050 REGIONAL INFLEX LOAD
C              X (CURRENT HOURLY LOAD / TOTAL YEARLY LOAD OVER ALL HOURS FOR
C              DATA THAT ARE AVAILABLE)
C MXHRDRM   = MAX NUMBER OF HOURS FORWARD THAT LOAD CAN BE SHIFTED BY
C             DEMAND-RESPONSE MANAGEMENT
C           = 24, 18, 16, 14 HOURS ALL WORK. 12 HOURS DOES NOT
C HPTURBRAT = RATIO OF NEEDED DISCHARGE RATE (TW) OF HYDROPOWER
C             TO 2050 INSTALLED DISCHARGE RATE (TW). ADDITIONAL DISCHARGE
C             OBTAINED BY ADDING TURBINES/GENERATORS/TRANSFORMERS WITHOUT
C             INCREASING SIZE OF DAM (HOLDING ANNUAL ENERGY OUTPUT CONSTANT)
C DAYBASHYD = DAYS OF BASELOAD HYDROPOWER STORAGE AT BASEHYD PEAK DISCHARGE RATE
C             DEFAULT = 60 DAYS. DECREASE TO <60 FOR MORE STORAGE FOR PEAKING
C             AS DAYBASHYD->0      ->BASHYDMX->0        ->ALL STORAGE FOR PEAKING
C             AS DAYBASHYD->HREFILL->BASHYDMX->HYDTWHMAX->ALL STORAGE FOR BASE
C FACONWIN  = FACTOR TO MULTIPLY DELIVERED ONSHORE WIND BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACOFFWIN = FACTOR TO MULTIPLY DELIVERED OFFSHORE WIND BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACRESPV  = FACTOR TO MULTIPLY NAMEPLATE CAPACITY OF RES ROOF PV HERE
C             TO IMPROVE MATCHING DEMAND WITH SUPPLY.
C FACCOMPV  = FACTOR TO MULTIPLY NAMEPLATE CAPACITY OF COM/GOV ROOF PV HERE
C             TO IMPROVE MATCHING DEMAND WITH SUPPLY.
C FACROOFPV = WEIGHTED AVG VALUE OF FACRESPV AND FACCOMPV
C             USED TO MULTIPLY DELIVERED TOTAL ROOFTOP PV FROM
C             GATOR-GCMOM BY
C FACUTILPV = FACTOR TO MULTIPLY DELIVERED UTILITY PV BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACSHT    = FACTOR TO MULTIPLY DELIVERED SOLAR THERMAL BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C           = 0. MEANS ALL HOT FLUID ORIGINATES FROM ELECTRICITY (LOWER EFFIC
C             THAN FROM SOLAR COLLECTORS BUT ALLOWS SOLAR PV, CSP TO BE USED
C             FOR ELECTRICITY PLUS HEAT) = 0, THEN NO HEAT FROM SOLAR
C             THERMAL COLLECTORS.
C CSPTURBFAC= RATIO OF MW OF CSP STEAM TURBINES DESIRED RELATIVE TO MW
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C             ORIGINALLY INSTALLED FOR EACH CSP PLANT IN ORDER TO MEET
C             ANNUALLY AVERAGED POWER DEMAND FOR STATE OR COUNTRY
C             BEFORE CONSIDERING THE GRID.
C           = 1.  INDICATES NO ADDITIONAL TURBINE POWER NEEDED TO MATCH DEMAND
C           = 1.6 INDICATES 60% MORE MW OF POWER NEEDED TO MATCH POWER DEMAND
C                 ON GRID THAN NEEDED FOR ANNUALLY AVERAGED POWER DEMAND.
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF LI BATTERIES
C HBTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF INDUSTRIAL HEAT BATTERIES
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C FCCHARG   = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C             USED WHEN IMERGH2=1,2,3 BUT NOT 0. WHEN IMERGH2=1,
C             FCCHARG IS REPLACED BY H2PEAKLD
C STORHHFC  = MAX HOURS H2 ELECTRICITY STORAGE AT MAX DISCHARGE RATE
C           = 0 WHEN IMERGH2 = 1,3, OR 0. APPLIES ONLY WHEN IMERGH2 = 2.
C DAMCAPRAT = RATIO OF HYDRO DAM ENERGY STORAGE CAPACITY TO ANNUAL
C             HYDRO ENERGY OUTPUT FOR REGION (TWH/TWH/Y = UNITS OF YEARS)
C             THIS IS THE FRACTION OF A YEAR THAT A HYDRO PLANT CAN
C             DISCHARGE AT ITS PEAK DISCHARGE RATE
C PHSMIN    = MIN PHS NAMEPLATE CAPAC (TW) IN 2050.
C             SET TO SMALLER OF A FIXED NUMBER AND NAMEPLATE HYDRO IN REGION
C             SINCE SOME REGIONS (E.G., JAMAICA, HAITI) NEED LESS THAN FIXED MIN
C STORHPHS  = MAX NUMBER HOURS PUMPED HYDRO STORAGE (PHS)
C FRSTORINIT= FRACTION (0-1) OF MAX STORAGE CAPACITY THAT THE STORAGE MEDIUM
C             HAS IN STORAGE AT THE BEGINNING OF THE SIMULATION. APPLIES TO
C             ALL STORAGE EXCEPT FOR HYDROPOWER, WHICH IS ASSUMED 95% FULL AT START
C UGFAC     = FACTOR TO MULTIPLY UTESCHARG BY TO INCREASE OR DECREASE
C             CHARGE RATE OF UTES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN GO ABOVE 1. HIGHER UGFAC-->MORE
C             EXPENSIVE COST OF HEAT PUMPS TO CHARGE STORAGE WITH
C             ELECTRICITY. IF UGFAC=0, THEN ONLY SOLAR COLLECTORS
C             (FACSHT) CAN SUPPLY UTES WITH HEAT .
C HWFAC     = FACTOR TO MULTIPLY HOTCHARGE BY TO INCREASE OR DECREASE
C             CHARGE RATE OF HW-STES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN BE ABOVE 1.
C FLDISELEC = FRAC (DEFAULT 0.3) OF ALL END-USE ELECTRICITY SUBJECT TO HVDC LONG-DIST
C             TRANSMISSION (1200-2000 KM). FOR SMALL REGIONS (E.G., ISLANDS),
C             TRANSMISSION DISTANCES ARE SMALLER THUS FLDISELEC SHOULD
C             BE PROPORTIONATELY SMALLER
C DAYH2STOR = NUMBER OF DAYS OF H2 STORAGE
C IFHPTURB  = 1: ADD HYDROPOWER TURBINES WITHOUT INCREASING ANNUAL AVERAGE
C                HYDRO OUTPUT TO SOME REGIONS (HPTURBRAT>1). HPTURBRAT
C                MAY = 1. IN THESE SCENARIOS, NO STATIONARY BATTERY STORAGE
C           = 0: HPTURBRAT MUST = 1. STORAGE WITH BATTERIES, CSP, ETC.
C FDISTHEAT = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C             USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C             DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C             THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C             HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C             WITHIN BUILDINGS WITH HEAT PUMPS.
C             GIVES DISTRICT HEATING VERSUS PROVIDING HEAT/COLD IN BUILDING
C             4TH GENERATION DISTRICT HEATING HAS HEATING & COOLING LOOPS
C HCDDADD   = ADD DUMMY HEATING AND COOLING DEGREE DAYS FOR EACH DAY OF
C             YEAR TO ENSURE MAXIMUM VALUES FOR COUNTRIES THAT HAVE FEW
C             HDD OR CDD DAYS DON'T RESULT IN ALL HEATING OR COOLING
C             FALLING ON ONE DAY. IN REALITY, SOME HEATING LOAD SHOULD
C             BE SPREAD OVER EVERY NIGHT FOR AIR AND WATER HEATING.
C             SIMILARLY, SOME COOLING OCCURS EVERY DAY FOR REFRIGERATION
C             ENSURE THAT HDDREG AND CDDREG HAVE A MINIMUM VALUE EACH DAYS BECAUSE
C             1) PEOPLE USE COLD AIR/WATER FOR REFRIG, COMPUTER COOLING EVEN IF DAY COLD
C                AND HOT AIR/WATER FOR SHOWERS, COOKING EVEN IF DAY IS HOT
C             2) IF HDDREG OR CDDREG = 0 EVERY DAY OF YEAR, THEN HEAT OR COLD LOAD IS
C                SET TO ZERO EVERY DAY ALTHOUGH A LOAD MAY ACTUALLY EXIST
C             3) IF HDDREG>0 ONLY ON ONE DAY OF YEAR, THE MAXIMUM HEAT LOAD = 365*TSTORAWH
C                SAME WITH COLD LOAD
C
C ***************************************************************************
C                  CONTINENTAL UNITED STATES (48 STATES)
C ***************************************************************************
C
      IF (IFCONUS.EQ.1) THEN
       GRIDLOAD   = 'CONUS'
       STORUGDYS  = 60.
       STORHHWAT  = 14.
```

```
       MXHRDRM    = 11
       HPTURBRAT  = 10.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.2
       DAYH2STOR  = 40
       FACONWIN   = 1.05
       FACOFFWIN  = 1.0
       FACUTILPV  = 1.0
       FACRESPV   = 1.0
       FACCOMPV   = 1.0
       CSPTURBFAC = 1.6
       FACSHT     = 1.0
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       PHSMIN     = 0.016
       FRSTORINIT = 0.5
       UGFAC      = 3.0
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                EAST AFRICA
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'AFRICA-EAST') THEN
       DEGXLON    = 37.9062
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.3
       FACOFFWIN  = 1.
       FACUTILPV  = 1.68
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.4
        BATDISCH   = 0.34
C       FCCHARG    = 0.005
C       FCDISCH    = 0.005
        FCCHARG    = 0.001
        FCDISCH    = 0.001
        DAYH2STOR  = 4.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.40
        FCCHARG    = 0.01
        FCDISCH    = 0.01
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.45
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
       STORUGDYS  = 9.
C
       PHSMIN     = 0.004
       FRSTORINIT = 0.9
       UGFAC      = 0.8
       HWFAC      = 0.8
       FLDISELEC  = 0.3
       HCDDADD    = 1.
```

```
C
C ***************************************************************************
C                              NORTH AFRICA
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'AFRICA-NORTH') THEN
       DEGXLON    = 9.5375
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
C      FACONWIN   = 1.24
       FACONWIN   = 1.23
       FACOFFWIN  = 1.
       FACUTILPV  = 1.
       FACRESPV   = 1.
C      FACRESPV   = 1.
       FACRESPV   = 0.97
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.15
        BATDISCH   = 0.13
C       FCCHARG    = 0.02
C       FCDISCH    = 0.02
        FCCHARG    = 0.015
        FCDISCH    = 0.015
        DAYH2STOR  = 6.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.40
        FCCHARG    = 0.01
        FCDISCH    = 0.01
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.45
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
       STORUGDYS  = 2.
C
       PHSMIN     = 0.004
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.9
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                               SOUTHERN AFRICA
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'AFRICA-SOUTH') THEN
       DEGXLON    = 22.9375
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.2
       FACOFFWIN  = 1.
       FACUTILPV  = 1.2
```

```
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.35
        BATDISCH   = 0.25
C       FCCHARG    = 0.03
C       FCDISCH    = 0.03
        FCCHARG    = 0.029
        FCDISCH    = 0.029
        DAYH2STOR  = 15.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.40
        FCCHARG    = 0.01
        FCDISCH    = 0.01
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.45
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
       STORUGDYS  = 2.
C
       PHSMIN     = 0.004
       FRSTORINIT = 0.9
       UGFAC      = 0.9
       HWFAC      = 0.9
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                WEST AFRICA
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'AFRICA-WEST') THEN
       DEGXLON    =  8.6753
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
       FACONWIN   = 3.8
C      FACOFFWIN  = 0.95
       FACOFFWIN  = 0.85
       FACUTILPV  = 1.
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.4
C       FCCHARG    = 0.04
C       FCDISCH    = 0.04
        FCDISCH    = 0.025
        FCCHARG    = 0.025
C       DAYH2STOR  = 11.
        DAYH2STOR  = 7.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.40
        FCCHARG    = 0.01
        FCDISCH    = 0.01
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.45
```

```
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
C      STORUGDYS  = 7.
       STORUGDYS  = 6.
C
       PHSMIN     = 0.004
       FRSTORINIT = 0.9
       UGFAC      = 0.9
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                           AFRICAN CONTINENT
C ***************************************************************************
C USE DAYBASHYD = 360 TO ENURE SUFFICIENT HYDRO USED FOR BASELOAD
C
      ELSEIF (GRIDUSE.EQ.'AFRICA') THEN
       DEGXLON    = 34.5085
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.24
       FACOFFWIN  = 1.
       FACUTILPV  = 1.
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.53
        FCCHARG    = 0.04
        FCDISCH    = 0.04
        DAYH2STOR  = 9.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.45
        FACUTILPV  = 1.2
        BATDISCH   = 0.
        FCCHARG    = 0.42
        FCDISCH    = 0.42
        DAYH2STOR  = 57.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.40
        FCCHARG    = 0.01
        FCDISCH    = 0.01
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.45
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
       STORUGDYS  = 25.
C
       PHSMIN     = 0.016
       FRSTORINIT = 0.9
       UGFAC      = 0.9
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                               AUSTRALIA
```

```
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'AUSTRALIA') THEN
       DEGXLON    = 133.7751
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.1
       FACOFFWIN  = 0.7
C      FACUTILPV  = 1.85
       FACUTILPV  = 1.84
       FACRESPV   = 0.75
       FACCOMPV   = 0.75
       CSPTURBFAC = 1.0
       FACSHT     = 0.1
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.12
        BATDISCH   = 0.11
C       FCCHARG    = 0.01
C       FCDISCH    = 0.01
        FCCHARG    = 0.009
        FCDISCH    = 0.009
C       DAYH2STOR  = 12.
        DAYH2STOR  = 10.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.45
        FACOFFWIN  = 3.9
        BATDISCH   = 0.
        FCCHARG    = 0.078
        FCDISCH    = 0.078
        DAYH2STOR  = 9.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.08
        FCCHARG    = 0.038
        FCDISCH    = 0.038
        STORHHFC   = 150.
        DAYH2STOR  = 10.
       ELSE
        BATDISCH   = 0.19
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 18.
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.006
       FRSTORINIT = 0.75
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                    CANADA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'CANADA') THEN
       DEGXLON    = -106.3468
       GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 8.
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.2
```

```
C      FACONWIN   = 1.28
       FACONWIN   = 1.4
C      FACOFFWIN  = 0.88
       FACOFFWIN  = 1.
       FACUTILPV  = 0.5
       FACRESPV   = 0.2
       FACCOMPV   = 0.69
       CSPTURBFAC = 0.
       FACSHT     = 0.2
C
       IF (IMERGH2.NE.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 0.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
        DAYH2STOR  = 0.
       ENDIF
C
C      STORUGDYS  = 2.
       STORUGDYS  = 0.

       PHSMIN     = 0.000177
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                            CENTRAL AMERICA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'CENTRAL-AMERIC') THEN
       DEGXLON    = -85.6024
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.0
C      FACOFFWIN  = 1.5
       FACOFFWIN  = 1.47
C      FACUTILPV  = 1.8
       FACUTILPV  = 1.63
       FACRESPV   = 0.7
       FACCOMPV   = 0.7
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.18
        BATDISCH   = 0.148
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 23.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACOFFWIN  = 2.8
        CSPTURBFAC = 4.
        BATDISCH   = 0.
        FCCHARG    = 0.016
        FCDISCH    = 0.016
        DAYH2STOR  = 7.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.11
        FCCHARG    = 0.038
        FCDISCH    = 0.038
```

```
        STORHHFC   = 120.
        DAYH2STOR  = 12.
       ELSE
        BATDISCH   = 0.79
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.006
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.2
       HCDDADD    = 1.
C
C ***************************************************************************
C                               CENTRAL ASIA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'CENTRAL-ASIA') THEN
       DEGXLON    = 68.8319
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREURASIA
       FDISTHEAT  = 0.01
C
       FACONWIN   = 2.0
       FACOFFWIN  = 0.9
       FACUTILPV  = 0.9
       FACRESPV   = 0.85
       FACCOMPV   = 0.85
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.09
        BATDISCH   = 0.035
C       FCCHARG    = 0.02
C       FCDISCH    = 0.02
        FCCHARG    = 0.021
        FCDISCH    = 0.021
        DAYH2STOR  = 6.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACUTILPV  = 0.93
        BATDISCH   = 0.
        FCCHARG    = 0.036
        FCDISCH    = 0.036
        DAYH2STOR  = 25.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.08
        FCCHARG    = 0.017
        FCDISCH    = 0.017
        STORHHFC   = 39.
        DAYH2STOR  = 3.
       ELSE
        BATDISCH   = 0.13
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 3.8
       ENDIF
C
       STORUGDYS  = 7.
C
       PHSMIN     = 0.012
       FRSTORINIT = 0.9
       UGFAC      = 0.3
       HWFAC      = 1.0
       FLDISELEC  = 0.3
```

```
       HCDDADD    = 1.
C
C ***************************************************************************
C                     CHINA-HONG KONG-MONGOLIA-NORTH KOREA
C ***************************************************************************
C OVER 50% DISTRICT HEATING IN NORTHERN CHINA
C https://www.sciencedirect.com/science/article/pii/S036054421730614X
C
      ELSEIF (GRIDUSE.EQ.'CHINA') THEN
       DEGXLON    = 104.1954
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 3.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRCHINA
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.4
       FACOFFWIN  = 0.7
       FACUTILPV  = 1.7
       FACRESPV   = 0.55
       FACCOMPV   = 0.55
       CSPTURBFAC = 1.
       FACSHT     = 0.34
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 1.
        BATDISCH   = 0.98
C       FCCHARG    = 0.5
C       FCDISCH    = 0.5
        FCCHARG    = 0.44
        FCDISCH    = 0.44
C       DAYH2STOR  = 24.
        DAYH2STOR  = 19.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.55
        BATDISCH   = 0.
        FCCHARG    = 0.65
        FCDISCH    = 0.65
        DAYH2STOR  = 35.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 1.32
        FCCHARG    = 0.15
        FCDISCH    = 0.15
        STORHHFC   = 4.
        DAYH2STOR  = 15.
       ELSE
        BATDISCH   = 1.69
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 12.
       ENDIF
C
C      STORUGDYS  = 11.
       STORUGDYS  = 5.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.90
       UGFAC      = 1.0
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                    CUBA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'CUBA') THEN
       DEGXLON    = -77.7812
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8.
       HPTURBRAT  = 1.
```

```
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.2
C
       FACONWIN   = 1.
       FACOFFWIN  = 1.
       FACUTILPV  = 1.9
       FACRESPV   = 1.
C      FACCOMPV   = 1.4
       FACCOMPV   = 1.39
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.048
        BATDISCH   = 0.041
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 1.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 4.6
        FACUTILPV  = 5.5
        BATDISCH   = 0.
        FCCHARG    = 0.02
        FCDISCH    = 0.02
        DAYH2STOR  = 59.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.021
        FCCHARG    = 0.005
        FCDISCH    = 0.005
        STORHHFC   = 135.
        DAYH2STOR  = 31.
        DAYH2STOR  = 32.
       ELSE
        BATDISCH   = 0.095
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 31.
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.003
       FRSTORINIT = 0.9
       UGFAC      = 0.4
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 2.
C
C ***************************************************************************
C                               EUROPE
C ***************************************************************************
C PERCENT DISTRICT HEATING: LATVIA (65%), DENMARK (63%), ESTONIA (62%),
C                           LITHUANIA (57%), SWEDEN (>50%), POLAND (>50%)
C                           FINLAND (>50%)
C
C (GRIDLOAD=GRIDUSE)
      ELSEIF (GRIDUSE.EQ.'EUROPE') THEN
       DEGXLON    = 15.2551
       GRIDLOAD   = GRIDUSE
C      GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 6.
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
C      FACONWIN   = 1.29
       FACONWIN   = 1.28
       FACOFFWIN  = 1.
C      FACUTILPV  = 1.25
       FACUTILPV  = 1.23
```

```
       FACRESPV   = 0.68
       FACCOMPV   = 0.9
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.015
        FCCHARG    = 0.21
        FCDISCH    = 0.21
C       DAYH2STOR  = 29.
        DAYH2STOR  = 27.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.225
        FCDISCH    = 0.225
        DAYH2STOR  = 36.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.605
        FCCHARG    = 0.03
        FCDISCH    = 0.03
        STORHHFC   = 24.
        DAYH2STOR  = 12.8
       ELSE
        BATDISCH   = 0.83
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 12.2
       ENDIF
C
C      STORUGDYS  = 5.
       STORUGDYS  = 1.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                        HAITI-DOMINICAN REPUBLIC
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'HAITI') THEN
       DEGXLON    = -72.2852
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 0.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.05
C
C      FACONWIN   = 4.
       FACONWIN   = 3.9
       FACOFFWIN  = 1.
C      FACUTILPV  = 1.6
       FACUTILPV  = 1.2
       FACRESPV   = 0.5
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.0
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.038
        FCDISCH    = 0.038
        DAYH2STOR  = 110.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 2.8
        FACUTILPV  = 6.0
        BATDISCH   = 0.
```

```
        FCCHARG    = 0.015
        FCDISCH    = 0.015
        DAYH2STOR  = 51.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.02
        FCCHARG    = 0.001
        FCDISCH    = 0.001
        STORHHFC   = 5.
        DAYH2STOR  = 14.
       ELSE
        BATDISCH   = 0.022
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 9.
       ENDIF
C
       STORUGDYS  = 1.2
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                ICELAND
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C 92% OF ICELAND CURRENTLY IS SUBJECT TO DISTRICT HEATING
C
      ELSEIF (GRIDUSE.EQ.'ICELAND') THEN
       DEGXLON    = -19.0208
       GRIDLOAD   = 'ICELAND'
C      GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 2.
       STORHHWAT  = 1.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 5.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.92
C
C      FACONWIN   = 0.63
       FACONWIN   = 0.62
       FACOFFWIN  = 0.
       FACUTILPV  = 0.
       FACRESPV   = 0.
       FACCOMPV   = 0.
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.NE.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 0.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
        DAYH2STOR  = 0.
       ENDIF
C
       STORUGDYS  = 0.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.5
       UGFAC      = 0.
       HWFAC      = 0.1
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
```

```
C                            INDIA-NEPAL-SRI LANKA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'INDIA') THEN
       DEGXLON    = 78.9629
       GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 8.
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.2
       FACOFFWIN  = 0.6
       FACUTILPV  = 1.4
       FACRESPV   = 0.1
       FACCOMPV   = 1.3
       CSPTURBFAC = 1.6
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 1.91
        BATDISCH   = 1.85
C       FCCHARG    = 0.25
C       FCDISCH    = 0.25
        FCCHARG    = 0.23
        FCDISCH    = 0.23
C       DAYH2STOR  = 55.
        DAYH2STOR  = 44.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.5
        BATDISCH   = 0.
        FCCHARG    = 1.2
        FCDISCH    = 1.2
        DAYH2STOR  = 30.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 1.5
        FCDISCH    = 0.355
        FCCHARG    = 0.355
        STORHHFC   = 35.
        DAYH2STOR  = 25.
       ELSE
        BATDISCH   = 4.1
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 1.
       ENDIF
C
C      STORUGDYS  = 24.
       STORUGDYS  = 21.
C
       PHSMIN     = 0.009
       FRSTORINIT = 0.95
       UGFAC      = 1.0
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                    ISRAEL
C ***************************************************************************
C DEGXLON = DEGREES LONGITUDE (+ IS EAST) IN MIDDEL OF REGION
C
      ELSEIF (GRIDUSE.EQ.'ISRAEL') THEN
       DEGXLON    = 34.85
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRMIDEAST
       FDISTHEAT  = 0.2
```

```
C
       FACONWIN   = 1.23
       FACOFFWIN  = 0.88
       FACUTILPV  = 2.60
       FACRESPV   = 0.1
       FACCOMPV   = 2.3
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.118
        BATDISCH   = 0.103
C       FCCHARG    = 0.005
C       FCDISCH    = 0.005
        FCCHARG    = 0.006
        FCDISCH    = 0.006
C       DAYH2STOR  = 32.
        DAYH2STOR  = 31.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.8
        FACUTILPV  = 3.5
        BATDISCH   = 0.
        FCCHARG    = 0.035
        FCDISCH    = 0.035
        DAYH2STOR  = 196.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.04
        FCCHARG    = 0.009
        FCDISCH    = 0.009
        STORHHFC   = 49.
        DAYH2STOR  = 32.
       ELSE
        BATDISCH   = 0.24
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 0.
       ENDIF
C
       STORUGDYS  = 25.
       FRSTORINIT = 0.9
C
       PHSMIN     = 0.
       UGFAC      = 0.7
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 2.
C
C ***************************************************************************
C                                JAMAICA
C ***************************************************************************
C NO NEED FOR IFHPTURB=1 SINCE SOLVES WITH 0 BATTERIES W/HPTURBRAT=1
C
      ELSEIF (GRIDUSE.EQ.'JAMAICA') THEN
       DEGXLON    = -77.2975
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.
C
       FACONWIN   = 0.75
       FACOFFWIN  = 1.4
       FACUTILPV  = 1.1
       FACRESPV   = 0.8
       FACCOMPV   = 1.
       CSPTURBFAC = 0.1
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.016
        BATDISCH   = 0.0145
        FCCHARG    = 0.
```

```
        FCDISCH    = 0.
C       DAYH2STOR  = 16.
        DAYH2STOR  = 15.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 1.6
        FACUTILPV  = 2.3
        BATDISCH   = 0.
        FCCHARG    = 0.006
        FCDISCH    = 0.006
        DAYH2STOR  = 15.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.01
        FCCHARG    = 0.0011
        FCDISCH    = 0.0011
        STORHHFC   = 20.
        DAYH2STOR  = 5.
       ELSE
        BATDISCH   = 0.015
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 5.
       ENDIF
C
       STORUGDYS  = 3.
C
       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.8
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                   JAPAN
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'JAPAN') THEN
       DEGXLON    = 138.2529
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.1
C
       FACONWIN   = 0.2
       FACOFFWIN  = 2.
       FACUTILPV  = 1.28
       FACRESPV   = 0.2
       FACCOMPV   = 0.2
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.20
        BATDISCH   = 0.17
C       FCCHARG    = 0.04
C       FCDISCH    = 0.04
        FCCHARG    = 0.039
        FCDISCH    = 0.039
        DAYH2STOR  = 30.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACUTILPV  = 1.9
        BATDISCH   = 0.
        FCCHARG    = 0.05
        FCDISCH    = 0.05
        DAYH2STOR  = 12.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.21
        FCCHARG    = 0.02
        FCDISCH    = 0.02
        STORHHFC   = 35.
```

```
        DAYH2STOR  = 9.
       ELSE
        BATDISCH   = 0.41
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 8.
       ENDIF
C
       STORUGDYS  = 5.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.9
       UGFAC      = 0.2
       HWFAC      = 0.1
       FLDISELEC  = 0.2
       HCDDADD    = 1.
C
C ***************************************************************************
C                               MADAGASCAR
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'MADAGASCAR') THEN
       DEGXLON    = 46.8691
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 360.
       DAMCAPRAT  = DCRAFRICA
       FDISTHEAT  = 0.1
C
C      FACONWIN   = 2.6
       FACONWIN   = 2.4
       FACOFFWIN  = 1.6
       FACUTILPV  = 4.
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.015
C       FCCHARG    = 0.0019
C       FCDISCH    = 0.0019
        FCCHARG    = 0.0021
        FCDISCH    = 0.0021
        DAYH2STOR  = 63.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.015
        FCCHARG    = 0.002
        FCDISCH    = 0.002
        STORHHFC   = 5.
        DAYH2STOR  = 22.
       ELSE
        BATDISCH   = 0.015
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 19.5
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.0004
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                 MAURITIUS
C ***************************************************************************
C                     CURRENTLY NO WIND/SOLAR DATA FOR MAURITIUS
C ***************************************************************************
C
```

```
      ELSEIF (GRIDUSE.EQ.'MAURITIUS') THEN
       DEGXLON    = 57.5522
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.2
C
       FACONWIN   = 1.
       FACOFFWIN  = 2.03
       FACUTILPV  = 1.5
       FACRESPV   = 0.2
       FACCOMPV   = 0.2
       CSPTURBFAC = 0.4
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.004
        BATDISCH   = 0.0036
C       FCCHARG    = 0.0022
C       FCDISCH    = 0.0022
        FCCHARG    = 0.0007
        FCDISCH    = 0.0007
        DAYH2STOR  = 30.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACOFFWIN  = 2.8
        FACUTILPV  = 1.9
        BATDISCH   = 0.
        FCCHARG    = 0.003
        FCDISCH    = 0.003
        DAYH2STOR  = 90.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.002
        FCCHARG    = 0.001
        FCDISCH    = 0.001
        STORHHFC   = 125.
        DAYH2STOR  = 60.
       ELSE
        BATDISCH   = 0.0105
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 47.
       ENDIF
C
       STORUGDYS  = 2.
C
       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  MIDEAST
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'MIDEAST') THEN
       DEGXLON    = 42.5510
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRMIDEAST
       FDISTHEAT  = 0.05
C
C      FACONWIN   = 1.8
       FACONWIN   = 1.87
       FACOFFWIN  = 0.8
       FACUTILPV  = 1.0
       FACRESPV   = 0.7
```

```
       FACCOMPV   = 0.75
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.85
        BATDISCH   = 0.6
C       FCCHARG    = 0.08
C       FCDISCH    = 0.08
        FCCHARG    = 0.05
        FCDISCH    = 0.05
C       DAYH2STOR  = 10.
        DAYH2STOR  = 4.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 2.45
        BATDISCH   = 0.
        FCCHARG    = 0.21
        FCDISCH    = 0.21
        DAYH2STOR  = 21.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.63
        FCCHARG    = 0.12
        FCDISCH    = 0.12
        STORHHFC   = 40.
        DAYH2STOR  = 7.
       ELSE
        BATDISCH   = 1.5
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 7.
       ENDIF
C
       STORUGDYS  = 30.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.9
       UGFAC      = 1.0
       HWFAC      = 1.0
       HWFAC      = 0.9
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                              NEW ZEALAND
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NEW-ZEALAND') THEN
       DEGXLON    = 174.8860
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.05
C
C      FACONWIN   = 2.5
       FACONWIN   = 1.98
       FACOFFWIN  = 3.
       FACUTILPV  = 1.95
       FACRESPV   = 0.6
       FACCOMPV   = 0.6
       CSPTURBFAC = 0.3
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.00029
        BATDISCH   = 0.
C       FCCHARG    = 0.0014
C       FCDISCH    = 0.0014
        FCCHARG    = 0.0005
        FCDISCH    = 0.0005
C       DAYH2STOR  = 2.
        DAYH2STOR  = 3.
```

```
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.0017
        FCDISCH    = 0.0017
        DAYH2STOR  = 7.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.0006
        FCDISCH    = 0.0011
        FCCHARG    = 0.0011
        STORHHFC   = 29.
        DAYH2STOR  = 3.
       ELSE
        BATDISCH   = 0.014
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 2.7
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                              PHILIPPINES
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'PHILIPPINES') THEN
       DEGXLON    = 121.7740
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.2
C
       FACONWIN   = 1.9
       FACOFFWIN  = 0.9
C      FACUTILPV  = 3.15
       FACUTILPV  = 2.4
       FACRESPV   = 0.55
       FACCOMPV   = 0.9
       CSPTURBFAC = 0.8
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 0.06
C       FCCHARG    = 0.03
C       FCDISCH    = 0.03
        FCCHARG    = 0.027
        FCDISCH    = 0.027
        DAYH2STOR  = 11.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACUTILPV  = 6.0
        BATDISCH   = 0.
        FCCHARG    = 0.1
        FCDISCH    = 0.1
        DAYH2STOR  = 48.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.11
        FCCHARG    = 0.041
        FCDISCH    = 0.041
        STORHHFC   = 25.
        DAYH2STOR  = 11.
       ELSE
        BATDISCH   = 0.311
        FCCHARG    = 0.
        FCDISCH    = 0.
```

```
        DAYH2STOR  = 9.
       ENDIF
C
       STORUGDYS  = 2.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.95
       UGFAC      = 0.2
       HWFAC      = 0.4
       FLDISELEC  = 0.2
       HCDDADD    = 1.
C
C ***************************************************************************
C                              RUSSIA-GEORGIA
C ***************************************************************************
C DISTRICT HEATING >50 %
C https://www.sciencedirect.com/science/article/pii/S036054421730614X
C
      ELSEIF (GRIDUSE.EQ.'RUSSIA') THEN
       DEGXLON    = 105.3188
       GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 10.
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREURASIA
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.76
       FACOFFWIN  = 0.55
       FACUTILPV  = 0.8
       FACRESPV   = 0.31
       FACCOMPV   = 0.32
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.NE.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
C       DAYH2STOR  = 7.2
        DAYH2STOR  = 6.9
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
        DAYH2STOR  = 7.4
       ENDIF
C
       STORUGDYS  = 7.
C
       PHSMIN     = 0.006
       FRSTORINIT = 0.75
       UGFAC      = 0.1
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                        NORTH-WEST SOUTH AMERICA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SOUTHAM-NW') THEN
       DEGXLON    = -71.5430
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.1
C
C      FACONWIN   = 1.5
```

```
       FACONWIN   = 1.41
       FACOFFWIN  = 0.72
       FACUTILPV  = 1.38
       FACRESPV   = 0.6
       FACCOMPV   = 0.6
C      CSPTURBFAC = 1.0
       CSPTURBFAC = 0.1
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
C       BATDISCH   = 0.05
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 1.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
        DAYH2STOR  = 1.
       ELSE
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 1.
       ENDIF
C
C      STORUGDYS  = 1.
       STORUGDYS  = 3.
       PHSMIN     = 0.008
       FRSTORINIT = 0.90
       UGFAC      = 0.1
       HWFAC      = 0.4
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                            SOUTH-EAST SOUTH AMERICA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SOUTHAM-SE') THEN
       DEGXLON    = -51.9253
       GRIDLOAD   = 'COUNTRY2030GW'
C      STORHHWAT  = 8.
       STORHHWAT  = 1.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.1
C
C      FACONWIN   = 1.25
       FACONWIN   = 1.15
C      FACOFFWIN  = 0.9
       FACOFFWIN  = 0.8
C      FACUTILPV  = 1.38
       FACUTILPV  = 1.46
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 0.1
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
C       BATDISCH   = 0.3
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
C       DAYH2STOR  = 10.
        DAYH2STOR  = 30.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
```

```
        DAYH2STOR  = 1.
       ELSE
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 1.
       ENDIF
C
       STORUGDYS  = 1.
       PHSMIN     = 0.008
       FRSTORINIT = 0.90
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                          ALL OF SOUTH AMERICA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SOUTH-AMERICA') THEN
       DEGXLON    = -55.4915
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 15.
       DAMCAPRAT  = DCRLATAM
       FDISTHEAT  = 0.1
C
       FACONWIN   = 1.65
       FACOFFWIN  = 0.65
       FACUTILPV  = 1.15
       FACRESPV   = 0.58
       FACCOMPV   = 0.6
       CSPTURBFAC = 1.0
       FACSHT     = 0.
C
       IF (IMERGH2.NE.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 2.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.
        FCCHARG    = 0.
        FCDISCH    = 0.
        STORHHFC   = 0.
        DAYH2STOR  = 2.
       ENDIF
C
       STORUGDYS  = 1.
C
       PHSMIN     = 0.016
       FRSTORINIT = 0.90
       UGFAC      = 0.1
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                               SOUTHEAST ASIA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SOUTHEAST-ASIA') THEN
       DEGXLON    = 104.9910
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.1
C
       FACONWIN   = 0.2
```

```
       FACOFFWIN  = 2.11
       FACUTILPV  = 1.7
       FACRESPV   = 1.
       FACCOMPV   = 1.
C      CSPTURBFAC = 1.
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
        BATDISCH   = 1.1
C       BATDISCH   = 1.
C       FCCHARG    = 0.09
C       FCDISCH    = 0.09
        FCCHARG    = 0.15
        FCDISCH    = 0.15
C       DAYH2STOR  = 66.
        DAYH2STOR  = 34.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACUTILPV  = 2.5
        BATDISCH   = 0.
        FCCHARG    = 0.98
        FCDISCH    = 0.98
        DAYH2STOR  = 56.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.97
        FCCHARG    = 0.08
        FCDISCH    = 0.08
        STORHHFC   = 7.
        DAYH2STOR  = 9.
       ELSE
        BATDISCH   = 1.28
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 8.
       ENDIF
C
       STORUGDYS  = 2.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.95
       UGFAC      = 0.4
       HWFAC      = 0.9
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                    SOUTH KOREA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SOUTH-KOREA') THEN
       DEGXLON    = 127.7669
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.15
C
       FACONWIN   = 0.1
       FACOFFWIN  = 2.
C      FACUTILPV  = 1.2
       FACUTILPV  = 1.15
       FACRESPV   = 0.9
C      FACCOMPV   = 2.5
       FACCOMPV   = 2.4
C      CSPTURBFAC = 0.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.26
        BATDISCH   = 0.27
C       FCCHARG    = 0.10
```

```
C       FCDISCH    = 0.10
        FCCHARG    = 0.11
        FCDISCH    = 0.11
        DAYH2STOR  = 37.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACOFFWIN  = 2.2
        FACUTILPV  = 2.0
        BATDISCH   = 0.
        FCCHARG    = 0.17
        FCDISCH    = 0.17
        DAYH2STOR  = 49.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.22
        FCCHARG    = 0.08
        FCDISCH    = 0.08
        STORHHFC   = 50.
        DAYH2STOR  = 15.
       ELSE
        BATDISCH   = 1.06
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 15.
       ENDIF

C      STORUGDYS  = 3.
       STORUGDYS  = 1.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.9
       UGFAC      = 0.4
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 5.
C
C ***************************************************************************
C                                  TAIWAN
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'TAIWAN') THEN
       DEGXLON    = 120.9605
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRASIAPAC
       FDISTHEAT  = 0.15
C
       FACONWIN   = 0.45
C      FACOFFWIN  = 1.7
       FACOFFWIN  = 1.6
       FACUTILPV  = 1.1
       FACRESPV   = 0.7
       FACCOMPV   = 3.
       CSPTURBFAC = 0.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 0.29
        BATDISCH   = 0.25
C       FCCHARG    = 0.026
C       FCDISCH    = 0.026
        FCCHARG    = 0.033
        FCDISCH    = 0.033
C       DAYH2STOR  = 99.
        DAYH2STOR  = 98.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACOFFWIN  = 2.4
        FACUTILPV  = 2.0
        BATDISCH   = 0.
        FCCHARG    = 0.16
        FCDISCH    = 0.16
        DAYH2STOR  = 58.
```

```
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 0.34
        FCCHARG    = 0.028
        FCDISCH    = 0.028
        STORHHFC   = 60.
        DAYH2STOR  = 55.
       ELSE
        BATDISCH   = 1.19
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 41.
       ENDIF

       STORUGDYS  = 2.
C
       PHSMIN     = 0.
       FRSTORINIT = 0.95
       UGFAC      = 0.2
       HWFAC      = 0.3
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                               UNITED STATES
C ***************************************************************************
C ABOUT 6.2% OF US FLOOR SPACE CURRENTLY COVERED BY DISTRICT HEATING;
C
      ELSEIF (GRIDUSE.EQ.'UNITED-STATES') THEN
       DEGXLON    = -95.7129
       GRIDLOAD   = 'COUNTRY2030GW'
C      GRIDLOAD   = 'CONUS'
C      GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 2.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.2

C FRCIHFLEX = 0.5; HDISSIP=1%,2%,3%
       FACONWIN   = 1.70
C HDISSIP=4%,5%
C      FACONWIN   = 1.72
C FRCIHFLEX = 0.
C      FACONWIN   = 1.75
C FRCIHFLEX = 0.1
C      FACONWIN   = 1.735
C FRCIHFLEX = 0.2
C      FACONWIN   = 1.725
C FRCIHFLEX = 0.3
C      FACONWIN   = 1.72
C FRCIHFLEX = 0.4
C      FACONWIN   = 1.715
C      FACONWIN   = 1.71
C      FACONWIN   = 1.705
C      FACONWIN   = 1.70
C
       FACOFFWIN  = 0.95
       FACUTILPV  = 2.34
       FACRESPV   = 0.45
       FACCOMPV   = 0.45
       CSPTURBFAC = 1.
       FACSHT     = 0.
C
       IF (IMERGH2.EQ.1) THEN
C       BATDISCH   = 1.5
C FRCIHFLEX = 0.5,0.4; HDISSIP=1%,2%,3%
        BATDISCH   = 1.17
C HDISSIP=4%,5%
C       BATDISCH   = 1.18
C FRCIHFLEX = 0.,0.1
C       BATDISCH   = 1.19
C FRCIHFLEX = 0.2, 0.3
C       BATDISCH   = 1.185
C
```

```
        FCCHARG    = 0.13
        FCDISCH    = 0.13
C       DAYH2STOR  = 35.
        DAYH2STOR  = 30.
C WITH NO BATTERIES
       ELSEIF (IMERGH2.EQ.3) THEN
        FACONWIN   = 2.2
        FACUTILPV  = 2.7
        BATDISCH   = 0.
        FCCHARG    = 0.8
        FCDISCH    = 0.8
        DAYH2STOR  = 79.
       ELSEIF (IMERGH2.EQ.2) THEN
        BATDISCH   = 1.55
        FCCHARG    = 0.091
        FCDISCH    = 0.091
        STORHHFC   = 13.
        DAYH2STOR  = 15.
       ELSE
        BATDISCH   = 2.9
        FCCHARG    = 0.
        FCDISCH    = 0.
        DAYH2STOR  = 13.1
       ENDIF

       STORUGDYS  = 4.
C HDISSIP=5%
C      STORUGDYS  = 5.
C
C DATA FROM FERC:
C https://www.ferc.gov/licensing/pumped-storage-projects
C LICENSES:                   18.897 GW MAY 22, 2023
C PENDING LICENSES:            3.672 GW MAY 22, 2023
C PRELIMINARY PERMITS:        41.2   GW MAY 22, 2023
C PENDING PRELIMINARY PERMITS: 49.5   GW
C TOTAL PENDING:              94.38  GW

       PHSMIN     = 0.
       FRSTORINIT = 0.9
       UGFAC      = 0.9
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                INDIVIDUAL + COMBINATIONS OF EUROPEAN COUNTRIES
C ***************************************************************************
C ***************************************************************************
C                           NORDEN = NORWAY + DENMARK
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NORDEN') THEN
       GRIDLOAD   = 'NORDEN'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.55
C
       FACONWIN   = 1.
       FACOFFWIN  = 1.
       FACUTILPV  = 0.6
       FACRESPV   = 0.6
       FACCOMPV   = 0.6
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 1.
       STORUGDYS  = 1.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
```

```
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C              NORDENSWEGER = NORWAY + DENMARK + SWEDEN + GERMANY
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NORDENSWEGER') THEN
       GRIDLOAD   = 'NORDENSWEGER'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.3
       FACOFFWIN  = 1.2
       FACUTILPV  = 1.2
       FACRESPV   = 1.
       FACCOMPV   = 2.8
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 1.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 20.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C      NODESWGENEBELU = NOR+DEN+SWE+GER+NET+BEL+LUX = NORTHERN EUROPE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NODESWGENEBELU') THEN
       GRIDLOAD   = 'NODESWGENEBELU'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.3
       FACONWIN   = 1.5
       FACOFFWIN  = 1.2
       FACUTILPV  = 1.1
       FACRESPV   = 1.
       FACCOMPV   = 2.7
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 1.4
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 17.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                          SWIGER = SWITZERLAND + GERMANY
C ***************************************************************************
```

```
C
      ELSEIF (GRIDUSE.EQ.'SWIGER') THEN
       GRIDLOAD   = 'SWIGER'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.4
C
       FACONWIN   = 1.5
       FACOFFWIN  = 1.
       FACUTILPV  = 1.5
       FACRESPV   = 1.
       FACCOMPV   = 2.9
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 1.2
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 10.
       STORUGDYS  = 10.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                         SWIFRA = SWITZERLAND + FRANCE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SWIFRA') THEN
       GRIDLOAD   = 'SWIFRA'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.4
C
       FACONWIN   = 1.3
       FACONWIN   = 1.6
       FACOFFWIN  = 1.
       FACUTILPV  = 0.9
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.15
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 10.
       STORUGDYS  = 5.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                          SWIITA = SWITZERLAND + ITALY
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SWIITA') THEN
       GRIDLOAD   = 'SWIITA'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
```

```
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.1
       FACOFFWIN  = 1.
       FACUTILPV  = 1.2
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.05
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 25.
       STORUGDYS  = 20.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                 NWEUROPE = NOR+DEN+SWE+GER+NET+BEL+LUX+FRA+SWI
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NWEUROPE') THEN
       GRIDLOAD   = 'NWEUROPE'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.3
       FACOFFWIN  = 1.2
       FACUTILPV  = 1.2
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.8
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                     SPAPORGIB = SPAIN + PORTUGAL + GIBRALTAR
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SPAPORGIB') THEN
       GRIDLOAD   = 'SPAPORGIB'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.3
       FACOFFWIN  = 0.8
       FACUTILPV  = 0.8
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 1.
       FACSHT     = 0.
```

```
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 20.
       STORUGDYS  = 20.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C        WESTEUROPE = NOR+DEN+SWE+GER+NET+BEL+LUX+FRA+SWI+ITA+SPA+POR+GIB
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'WESTEUROPE') THEN
       GRIDLOAD   = 'WESTEUROPE'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.3
       FACOFFWIN  = 1.
       FACUTILPV  = 1.15
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  GERMANY
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'GERMANY') THEN
       GRIDLOAD   = 'GERMANY'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.5
       FACOFFWIN  = 1.25
       FACUTILPV  = 2.
       FACRESPV   = 1.
       FACCOMPV   = 3.
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 1.3
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 10.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
```

```
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                UNITED KINGDOM
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'UNITED-KINGDOM') THEN
       GRIDLOAD   = 'UNITED-KINGDOM'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.5
       FACOFFWIN  = 1.2
       FACUTILPV  = 1.8
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.5
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  FRANCE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'FRANCE') THEN
       GRIDLOAD   = 'FRANCE'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.4
       FACOFFWIN  = 0.95
       FACUTILPV  = 2.2
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.5
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 5.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  NORWAY
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NORWAY') THEN
```

```
       GRIDLOAD   = 'NORWAY'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 0.8
       FACOFFWIN  = 0.8
       FACUTILPV  = 0.5
       FACRESPV   = 0.5
       FACCOMPV   = 0.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 1.
       STORUGDYS  = 1.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                SWEDEN
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SWEDEN') THEN
       GRIDLOAD   = 'SWEDEN'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 1.
       FACOFFWIN  = 1.
       FACUTILPV  = 1.
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.2
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 40.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                DENMARK
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'DENMARK') THEN
       GRIDLOAD   = 'DENMARK'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.63
C
       FACONWIN   = 2.5
```

```
       FACOFFWIN  = 2.3
       FACUTILPV  = 0.8
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.2
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                                NETHERLANDS
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NETHERLANDS') THEN
       GRIDLOAD   = 'NETHERLANDS'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 2.
       FACOFFWIN  = 1.5
       FACUTILPV  = 1.5
       FACRESPV   = 0.7
       FACCOMPV   = 1.2
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.55
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 10.
       STORUGDYS  = 5.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                                BELGIUM
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'BELGIUM') THEN
       GRIDLOAD   = 'BELGIUM'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 2.0
       FACOFFWIN  = 1.8
       FACUTILPV  = 1.3
       FACRESPV   = 0.7
       FACCOMPV   = 0.7
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.3
       FCCHARG    = 0.
       FCDISCH    = 0.
```

```
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                                LUXEMBOURG
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'LUXEMBOURG') THEN
       GRIDLOAD   = 'LUXEMBOURG'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.5
C
       FACONWIN   = 4.5
       FACOFFWIN  = 0.
       FACUTILPV  = 1.
       FACRESPV   = 1.4
       FACCOMPV   = 1.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.12
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 50.
       STORUGDYS  = 50.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                SWITZERLAND
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SWITZERLAND') THEN
       GRIDLOAD   = 'SWITZERLAND'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 0.5
       FACOFFWIN  = 0.
       FACUTILPV  = 0.5
       FACRESPV   = 0.5
       FACCOMPV   = 0.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 1.
       STORUGDYS  = 1.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.1
       HCDDADD    = 1.
```

```
C
C ***************************************************************************
C                                 SPAIN
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SPAIN') THEN
       GRIDLOAD   = 'SPAIN'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.3
       FACOFFWIN  = 0.8
       FACUTILPV  = 0.8
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.05
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 25.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                PORTUGAL
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'PORTUGAL') THEN
       GRIDLOAD   = 'PORTUGAL'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.35
       FACOFFWIN  = 0.8
       FACUTILPV  = 1.1
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 1.
       FACSHT     = 0.
       BATDISCH   = 0.15
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 35.
       STORUGDYS  = 35.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ***************************************************************************
C                                GIBRALTAR
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'GIBRALTAR') THEN
       GRIDLOAD   = 'COUNTRY2030GW'
       STORHHWAT  = 6.
       MXHRDRM    = 8
```

```
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 0.
       FACOFFWIN  = 0.9
       FACUTILPV  = 0.1
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.02
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ********************************************************************************
C                                ITALY
C ********************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'ITALY') THEN
       GRIDLOAD   = 'ITALY'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.3
C
       FACONWIN   = 1.1
       FACOFFWIN  = 1.
       FACUTILPV  = 1.2
       FACRESPV   = 0.8
       FACCOMPV   = 0.8
       CSPTURBFAC = 1.4
       FACSHT     = 0.
       BATDISCH   = 0.2
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 15.
C
       PHSMIN     = 0.002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.15
       HCDDADD    = 1.
C
C ********************************************************************************
C                                CANARY ISLANDS
C ********************************************************************************
C                                GRAN CANARIA
C ********************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'GRAN-CANARIA') THEN
       GRIDLOAD   = 'GRAN-CANARIA'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.
C      FACOFFWIN  = 1.78
```

```
       FACOFFWIN  = 1.7
       FACUTILPV  = 2.8
       FACUTILPV  = 1.28
       FACRESPV   = 0.91
C      FACCOMPV   = 1.45
       FACCOMPV   = 2.75
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 0.024
       BATDISCH   = 0.014
       FCCHARG    = 0.
       FCDISCH    = 0.
C      DAYH2STOR  = 20.
       DAYH2STOR  = 13.
C      STORUGDYS  = 10.
       STORUGDYS  = 3.
C
C MAX PHS (FROM JS): 0.0005145 TW; 15.28 HOURS
C
C      PHSMIN     = 0.00001
       PHSMIN     = 0.0005
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                            LANZAROTE-FUERTEVENTURA
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'LANZAROTE-FV') THEN
       GRIDLOAD   = 'LANZAROTE-FV'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 2.3
       FACOFFWIN  = 1.
       FACUTILPV  = 3.4
       FACRESPV   = 1.
       FACCOMPV   = 2.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.0035
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 1.
C
C MAX PHS (FROM JS): 0.0000465 TW; 4.6 HOURS
C
       PHSMIN     = 0.00004
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  TENERIFE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'TENERIFE') THEN
       GRIDLOAD   = 'TENERIFE'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
```

```
       FACONWIN   = 1.
       FACOFFWIN  = 1.89
       FACUTILPV  = 1.
       FACRESPV   = 0.5
       FACCOMPV   = 3.25
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.010
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 18.
       STORUGDYS  = 3.
C
C MAX PHS (FROM JS): 0.0005677 TW; 12 HOURS
C
       PHSMIN     = 0.0004
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ******************************************************************************
C                                    LA PALMA
C ******************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'LA-PALMA') THEN
       GRIDLOAD   = 'LA-PALMA'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.53
       FACOFFWIN  = 0.
       FACUTILPV  = 1.68
       FACRESPV   = 1.
       FACCOMPV   = 3.27
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 1.
C
C MAX PHS (FROM JS): 0.000204 TW; 15.5 HOURS
C
       PHSMIN     = 0.0002
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ******************************************************************************
C                                    LA GOMERA
C ******************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'LA-GOMERA') THEN
       GRIDLOAD   = 'LA-GOMERA'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.4
       FACOFFWIN  = 1.
       FACUTILPV  = 2.8
       FACRESPV   = 1.
       FACCOMPV   = 1.8
```

```
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 1.
C
C MAX PHS (FROM JS): 0.000085 TW; 12 HOURS
C
       PHSMIN     = 0.000085
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                                  EL HIERRO
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'EL-HIERRO') THEN
       GRIDLOAD   = 'EL-HIERRO'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.6
       FACOFFWIN  = 1.
       FACUTILPV  = 1.8
       FACRESPV   = 1.
       FACCOMPV   = 1.95
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 15.
       STORUGDYS  = 5.
C
C MAX PHS (FROM JS): 0.0000113 TW; 25.2 HOURS
C
       PHSMIN     = 0.00001
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1
C
C ***************************************************************************
C                    LANZAROTE-FUERTEVENTURA WITH CSP
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'LANZ-FV-CSP') THEN
       GRIDLOAD   = 'LANZAROTE-FV'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 10.
       FACOFFWIN  = 8.
       FACUTILPV  = 2.
       FACRESPV   = 1.
       FACCOMPV   = 2.
       CSPTURBFAC = 2.2
       FACSHT     = 0.
       BATDISCH   = 0.0029
       FCCHARG    = 0.
       FCDISCH    = 0.
```

```
       DAYH2STOR  = 18.
       STORUGDYS  = 1.
C
C MAX PHS (FROM JS): 0.0000465 TW; 4.6 HOURS
C
       PHSMIN     = 0.00004
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                GRAN CANARIA-LANZAROTE-FUERTEVENTURA INTERCONNECTED
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'GRANCAN-LZFT') THEN
       GRIDLOAD   = 'GRANCAN-LZFT'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.5
       FACOFFWIN  = 1.6
       FACUTILPV  = 1.5
       FACRESPV   = 0.9
       FACCOMPV   = 2.75
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.014
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 6.
       STORUGDYS  = 1.
C
C MAX PHS GRAN-CANARIA : 0.0005145 TW; 15.28 HOURS
C MAX PHS LANZAROTE-FV:  0.0000465 TW; 4.6 HOURS
C MAX PHS TOTAL:         0.000561  TW
C
       PHSMIN     = 0.00056
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                      TENERIFE-LA GOMERA INTERCONNECTED
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'TENER-LAGOM') THEN
       GRIDLOAD   = 'TENER-LAGOM'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.
       FACONWIN   = 1.2
       FACOFFWIN  = 1.75
       FACUTILPV  = 1.
       FACRESPV   = 0.5
       FACCOMPV   = 3.25
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.0089
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 19.
       STORUGDYS  = 3.
```

```
C
C MAX PHS TENERIFE:  0.0005677 TW; 12 HOURS
C MAX PHS LA GOMERA: 0.000085  TW; 12 HOURS
C MAX PHS TOTAL:     0.0006527 TW; 12 HOURS
C
       PHSMIN     = 0.00065
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                     ALL SIX CANARY ISLANDS INTERCONNECTED
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'ALL-CANARY') THEN
       GRIDLOAD   = 'ALL-CANARY'
       STORHHWAT  = 6.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCREUROPE
       FDISTHEAT  = 0.
C
       FACONWIN   = 1.3
       FACOFFWIN  = 1.
       FACUTILPV  = 4.5
       FACRESPV   = 1.
       FACCOMPV   = 1.3
       CSPTURBFAC = 0.
       FACSHT     = 0.
       BATDISCH   = 0.038
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 10.
       STORUGDYS  = 1.
C
C MAX PHS GRAN-CANARIA: 0.0005145 TW; 15.28 HOURS
C MAX PHS LANZAROTE-FV: 0.0000465 TW; 4.6 HOURS
C MAX PHS TENERIFE:     0.0005677 TW; 12 HOURS
C MAX PHS LA PALMA:     0.000204  TW; 15.5 HOURS
C MAX PHS LA GOMERA:    0.000085  TW; 12 HOURS
C MAX PHS EL HIERRO:    0.0000113 TW; 25.2 HOURS
C MAX PHS TOTAL:        0.001429  TW
C
       PHSMIN     = 0.0001
C      PHSMIN     = 0.0014
       FRSTORINIT = 0.9
       UGFAC      = 1.5
       HWFAC      = 1.0
       FLDISELEC  = 0.3
       HCDDADD    = 1.
C
C ***************************************************************************
C                   INDIVIDUAL OR GROUPS OF THE 50 US STATES + DC
C ***************************************************************************
C               WECC  = WESTERN ELECTRICITY COORDINATING COUNCIL
C   Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon,
C                         Utah, Washington State, Wyoming
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'WECC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.
       FACOFFWIN  = 1.
       FACUTILPV  = 1.9
       FACRESPV   = 1.
```

```
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C      BATDISCH   = 0.5
       BATDISCH   = 0.247
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 30.
       STORUGDYS  = 20.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                    MRO   = MIDWEST RELIABILITY ORGANIZATION
C Iowa, Kansas, Minnesota, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'MRO') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.15
       FACOFFWIN  = 0.9
       FACUTILPV  = 1.9
       FACRESPV   = 1.
       FACCOMPV   = 1.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 1.55
       BATDISCH   = 0.57
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 20.
       STORUGDYS  = 1.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                     TRE = TEXAS RELIABILITY ENTITY - Texas
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'TRE') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.7
       FACOFFWIN  = 1.5
       FACUTILPV  = 2.69
       FACRESPV   = 2.
       FACCOMPV   = 2.
       CSPTURBFAC = 1.9
       FACSHT     = 0.
C      BATDISCH   = 7.
       BATDISCH   = 3.35
       FCCHARG    = 0.
```

```
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 1.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                        RFC = RELIABILITY FIRST CORPORATION
C      Delaware, Indiana, Maryland, Michigan, New Jersey, Ohio, Pennsylvania,
C                         Washington D.C., West Virginia
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'RFC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.
       FACOFFWIN  = 2.
       FACUTILPV  = 1.8
       FACRESPV   = 1.
       FACCOMPV   = 1.5
       FACCOMPV   = 2.3
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 2.5
       BATDISCH   = 1.13
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 5.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                   SERC = SOUTHEASTERN ELECTRIC RELIABILITY COUNCIL
C Alabama, Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi,
C           Missouri, North Carolina, South Carolina, Tennessee, Virginia
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'SERC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.2
       FACOFFWIN  = 1.95
       FACUTILPV  = 2.2
       FACRESPV   = 1.5
       FACCOMPV   = 1.2
       CSPTURBFAC = 0.7
       CSPTURBFAC = 0.5
       FACSHT     = 0.
C      BATDISCH   = 3.
       BATDISCH   = 1.37
       FCCHARG    = 0.
       FCDISCH    = 0.
```

```
       DAYH2STOR  = 10.
       STORUGDYS  = 20.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                     NPCC = NORTHEAST POWER COORDINATING COUNCIL
C Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NPCC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 0.6
       FACOFFWIN  = 2.2
       FACUTILPV  = 1.8
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 1.3
       BATDISCH   = 0.58
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 35.
       STORUGDYS  = 10.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                       ASCC = ALASKA SYSTEM COORDINATING COUNCIL
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'ASCC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 0.9
       FACOFFWIN  = 0.5
       FACUTILPV  = 0.5
       FACRESPV   = 0.5
       FACCOMPV   = 0.5
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 0.4
       BATDISCH   = 0.188
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 5.
       STORUGDYS  = 1.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
```

```
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                     HICC = HAWAIIAN ISLANDS COORDINATING COUNCIL
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'HICC') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.9
       FACOFFWIN  = 2.4
       FACUTILPV  = 2.
       FACRESPV   = 0.5
       FACCOMPV   = 0.7
       CSPTURBFAC = 1.4
       FACSHT     = 0.
C      BATDISCH   = 0.055
       BATDISCH   = 0.0223
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 32.
       STORUGDYS  = 1.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 0.1
       HWFAC      = 0.1
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                               CALI = CALIFORNIA ALONE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'CALI') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.
       FACOFFWIN  = 1.
       FACUTILPV  = 2.
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C      BATDISCH   = 1.1
       BATDISCH   = 0.507
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 40.
       STORUGDYS  = 20.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                               FLA = FLORIDA ALONE
C ***************************************************************************
```

```
C
      ELSEIF (GRIDUSE.EQ.'FLA') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 0.7
       FACOFFWIN  = 1.2
       FACUTILPV  = 2.9
       FACRESPV   = 0.95
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C      BATDISCH   = 0.6
       BATDISCH   = 0.262
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 25.
       STORUGDYS  = 20.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C                             NEWY = NEW YORK STATE ALONE
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'NEWY') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.
       FACOFFWIN  = 3.2
       FACUTILPV  = 1.
       FACRESPV   = 1.
       FACCOMPV   = 1.4
       CSPTURBFAC = 0.
       FACSHT     = 0.
C      BATDISCH   = 1.45
       BATDISCH   = 0.6
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 60.
       STORUGDYS  = 1.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.
       HCDDADD    = 1.
C
C ***************************************************************************
C               TXMRO = TEXAS + MRO (IA,KS,MN,NE,ND,OK,SD,WI)
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'TXMRO') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
```

```
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.1
       FACOFFWIN  = 1.1
       FACUTILPV  = 2.6
       FACRESPV   = 1.
       FACCOMPV   = 1.
       CSPTURBFAC = 1.
       FACSHT     = 0.
C      BATDISCH   = 6.63
       BATDISCH   = 3.05
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 4.
       STORUGDYS  = 3.

       PHSMIN     = 0.0001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.1
       HCDDADD    = 1.
C
C ***************************************************************************
C                                 USCON = 48 STATES + DC
C ***************************************************************************
C
      ELSEIF (GRIDUSE.EQ.'USCON') THEN
       GRIDLOAD   = 'CONUS2016-19'
       STORHHWAT  = 8.
       MXHRDRM    = 8
       HPTURBRAT  = 1.
       DAYBASHYD  = 60.
       DAMCAPRAT  = DCRNORTHAM
       FDISTHEAT  = 0.1

       FACONWIN   = 1.15
       FACOFFWIN  = 1.5
       FACUTILPV  = 1.35
       FACRESPV   = 1.
       FACCOMPV   = 1.4
       CSPTURBFAC = 0.9
       FACSHT     = 0.
C      BATDISCH   = 9.5
       BATDISCH   = 3.71
       FCCHARG    = 0.
       FCDISCH    = 0.
       DAYH2STOR  = 24.
       STORUGDYS  = 11.

       PHSMIN     = 0.001
       FRSTORINIT = 0.9
       UGFAC      = 1.
       HWFAC      = 1.
       FLDISELEC  = 0.2
       HCDDADD    = 1.
      ENDIF
C     ENDIF GRIDUSE
C
C ***************************************************************************
C                        FIND TIME ZONE IN MIDDLE OF DOMAIN
C ***************************************************************************
C DEGXLON = DEGREES LONGITUDE (+ IS EAST) IN MIDDEL OF REGION
C ITZONE  = TIME ZONE (HR) OF CURRENT LONGITUDE (-12 TO +12)
C         = LONGITUDE DISTANCE (HOURS) BETWEEN
C           GREENWICH AND BEGINNING OF LOCAL TIME ZONE
C         = -5 IF XLONDEG= -67.5 TO -82.5
C         =  0 IF XLONDEG= - 7.5 TO + 7.5
C         = +5 IF XLONDEG= +67.5 TO +82.5
C
      IF (DEGXLON.GT.7.5) THEN
       ITZONE = 1. + (DEGXLON - 7.5) / 15.
      ELSEIF (DEGXLON.LT.-7.5) THEN
       ITZONE = (DEGXLON + 7.5) / 15. - 1.
```

```
      ELSE
       ITZONE = 0.
      ENDIF
C
C ***************************************************************************
C                            SET SOME PARAMETERS
C ***************************************************************************
C INITYLOAD = INITIAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED.
C             IF ONLY 1 YEAR OF LOAD DATA -->
C             INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2006 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IFINYLOAD = FINAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED
C             IF ONLY 1 YEAR OF LOAD DATA -->
C             INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2007 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IBEGYLOAD = YEAR BETWEEN AND INCLUSIVE OF INITYLOAD AND IFINYLOAD
C             THAT LOAD DATA STARTS. SO, FOR EXAMPLE, IF
C             IF ONLY 1 YEAR OF LOAD DATA -->
C             INITYLOAD=IFINYLOAD=IBEGYLOAD
C             SUPPOSE INITYLOAD = 2006 AND IFINYLOAD=2007 AND NYEARS=6
C             AND IBEGYLOAD = 2007, THEN LOAD DATA USED IN THE FOLLOWING
C             ORDER:
C             2007 2006 2007 2006 2007 2006 .
C             SUPPOSE INITYLOAD = 2013 AND IFINYLOAD=2015 AND NYEARS=6
C             AND IBEGYLOAD=2013 THEN ORDER IS: 2013 2014 2015 2013 2014
C IYBEFORE  = YEAR BEFORE START OF DATA IN loadreg.XXX FILES
C             THUS, FOR DATA FROM 2006-2016, IYBEFORE = 2005
C
C THESE PARAMETERS (IYBEFORE, INITYLOAD, IFINYLOAD, IBEGYLOAD) NEEDED
C ONLY WHEN GRIDLOAD.NE.'COUNTRY2030GW'
C
      IF (GRIDLOAD.EQ.'CONUS') THEN
       IYBEFORE  = 2005
       INITYLOAD = 2006
       IFINYLOAD = 2007
       IBEGYLOAD = 2006
C      IBEGYLOAD = 2007
C
       IF (INITYLOAD.NE.2006.AND.IFINYLOAD.NE.2007) THEN
        WRITE(IOUT,*) 'POWERWORLD: INITYLOAD NE 2006 ',
     1                INITYLOAD,IFINYLOAD
        STOP
       ENDIF
C
C U.S. STATES (STATELOAD) (IFSTATES=1)
C  WHEN IFSTATES=1, LOAD DATA ARE FROM 2016-2019. SO WHEN INITYEAR=2050,
C  START WITH 2018 (NON-LEAP YEAR) SO THAT BY 2052, CYCLES BACK TO 2016
C  (LEAP YEAR)
C
      ELSEIF (IFSTATES.EQ.1) THEN
       IYBEFORE  = 2015
       INITYLOAD = 2016
       IFINYLOAD = 2019
       IBEGYLOAD = 2018
C
       IF (INITYEAR.EQ.2050.AND.IBEGYLOAD.NE.2018) THEN
        WRITE(IOUT,*)'INITYEAR=2050. NEED TO START ON NONLEAP YEAR ',
     1               INITYEAR, IBEGYLOAD0
        STOP
       ENDIF
C
C CANARY ISLANDS (IFCANARY=1)
C
      ELSEIF (IFCANARY.EQ.1) THEN
       IYBEFORE  = 2017
       INITYLOAD = 2018
       IFINYLOAD = 2018
       IBEGYLOAD = 2018
C
C GRIDLOAD = 'EUROPE' OR INDIVIDUAL COUNTRIES WITH DATA FROM EUROPE
C
      ELSE
       IYBEFORE  = 2005
```

```
       INITYLOAD = 2010
       IFINYLOAD = 2015
       IBEGYLOAD = 2010
      ENDIF
C
C LOAD DATA CURRENTLY DIMENSIONED FOR 2006 TO 2016.
C
      IF (IFINYLOAD.GT.IYBEFORE+MXYLOAD) THEN
       WRITE(IOUT,*)'POWERWORLD: IFINYLOAD>IYBEFORE+MXYLOAD ',
     1              'DEC IFINYLOAD OR INC MXYLOAD ',
     1               IFINYLOAD,IYBEFORE+MXYLOAD
       STOP
      ENDIF
C
      IF (IBEGYLOAD.LT.INITYLOAD.OR.IBEGYLOAD.GT.IFINYLOAD) THEN
       WRITE(IOUT,*) 'POWERWORLD: IBEGYLOAD OUT BOUNDS ', IBEGYLOAD,
     1               INITYLOAD,IFINYLOAD
       STOP
      ENDIF
C
C ***************************************************************************
C                      HOURS OF STORAGE FOR DIFFERENT TECHS
C ***************************************************************************
C HCHARCSP  = MAX NUMBER HOURS THAT CSP CAN BE CHARGED FOR AT RATE CSPCHSTO
C             TO REACH FULL CAPACITY OF STORCTWH
C STORHCOLD = MAX NUMBER HOURS PHASE-CHANGE MATERIAL (PCM)-ICE AND
C             CHILLED-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE (CW STES)
C STORHPHS  = MAX NUMBER HOURS PUMPED HYDRO STORAGE (PHS)
C STORHHWAT = MAX NUMBER HOURS HOT-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE
C STORHBAT  = MAX HOURS BATTERY STORAGE AT MAX DISCHARGE RATE
C             USE TESLA POWERWALL EXAMPLE: 6.4 KWH, 3.3 KW MAX CHARGE/DISCHARGE
C             --> 1.94 HOURS STORAGE AT MAX DISCHARGE RATE
C             USE TESLA POWERPACK 4-H STORAGE https://www.tesla.com/powerpack
C                 232 KWH AC; 58 KW PEAK DISCHARGE RATE; 100% DEPTH DISCHARGE
C                 89.5% ROUND-TRIP EFFICIENCY
C STORHHBT  = MAX HOURS OF STORAGE AT MAX DISCHARGE RATE HEAT BATTERIES
C           = 15 H (300 MWH/20 MW PEAK DISCHARGE) RHB300 RANDO DATASHEET
C
      HCHARCSP  = 14.0
      STORHCOLD = 14.0
      STORHPHS  = 14.0
      STORHBAT  = 4.0
      STORHHBT  = 15.0
C
C STORUGDYS = DAYS OF UNDERGROUND SEAS HEAT STORAGE IN SOIL OR WATER (UTES)(HRS)
C             DRAKE LANDING STORAGE SUPPLIES 100% OF WINTER AIR HEAT (90 DAYS)
C STORUGHRS = HOURS OF UNDERGROUND SEAS HEAT STORAGE IN SOIL OR WATER (UTES)(HRS)
C HRSPDAY   = NUMBER OF HOURS PER DAY (24)
C
      STORUGHRS = HRSPDAY * STORUGDYS
C
C CSPTURBFAC = RATIO OF MW OF CSP STEAM TURBINES DESIRED RELATIVE TO MW
C              ORIGINALLY INSTALLED FOR EACH CSP PLANT IN ORDER TO MEET
C              ANNUALLY AVERAGED POWER DEMAND FOR STATE OR COUNTRY
C              BEFORE CONSIDERING THE GRID.
C            = 1.  INDICATES NO ADDITIONAL TURBINE POWER NEEDED TO MATCH DEMAND
C            = 1.6 INDICATES 60% MORE MW OF POWER NEEDED TO MATCH POWER DEMAND
C                ON GRID THAN NEEDED FOR ANNUALLY AVERAGED POWER DEMAND.
C CSPSTORGAT = RATIO OF MAX CHARGE RATE (TW) OF CSP DIRECTLY-USED+STORED
C              ELECTRICITY TO DISCHARGE RATE (CSPDISCH) OF CSP GENERATORS.
C              THE NUMBER/SIZE OF MIRRORS IS ASSOCIATED WITH THE CHARGE RATE OF
C              STORAGE+DIRECT ELECTRICITY. GENERATOR SIZE ASSOC W/DISCHARGE RATE.
C            = 1->NO STORAGE.ALL CSP FOR ELEC AT CHARGE/DISCHARGE RATE CSPDISCH
C            = 2.6 --> TOTAL ELECTRICITY COLLECTION AT RATE 2.6 X CSPDISCH,
C              WHERE 1.6 X CSPDISCH FOR STORAGE & 1.0 X CSPDISCH FOR DIRECT ELEC
C              CSPSTORGAT MUST EQUAL CSPSTORG IN reader.f IN GATOR-GCMOM
C            = SET AT 2.6169 BEFORE 8/30/2015 AND 2.61244594 AFTER 8/30/2015
C            = CSPCHARFAC / CSPTURBFAC AT TIME OF GATOR-GCMOM SIMULATION
C              FOR U.S. STATES OR 145 COUNTRIES, USE VALUE IN xlsx-spreadsheets
C              AT web.stanford.edu/group/efmh/jacobson/Articles/I/
C              WWS-50-USState-plans.html 'Tables for GATOR-GCMOM' TAB CELL A7
C CSPCHARFAC = CSPTURBFAC * CSPSTORGAT = FACTOR THAT CSP GENERATOR SIZE (TW)
C              USED FOR ANNUALLY-AVERAGED POWER IN xlsx-spreadsheets IS
C              MULTIPLIED BY TO ACCOUNT FOR ADDITIONAL GENERATORS NEEDED TO
C              KEEP GRID STABLE (CSTPURBFAC) AND TO ACCOUNT FOR ADDITIONAL
```

```
C              MIRRORS NEEDED FOR STORAGE PLUS THOSE MIRRORS NEEDED FOR DIRECT
C              ELECTRICITY (CSPSTORGAT).
C              CSPCHARFAC NOT USED HERE, BUT CSPTURBFAC AND CSPSTORGAT ARE
C              HOWEVER, CSPCHARFAC NEEDED IN xlsx-spreadsheets.
C            = 4.17991351 WHEN CSPTURBFAC=1.6 ANND CSPSTORGAT=2.61244594
C
C CSPTURBFAC=1.6 WAS USED IN FINAL CONUS SIMULATIONS (IFCONUS=1)
C CSPTURBFAC=1.6 WAS USED IN 143-COUNTRY SIMULATIONS
C CSPTURBFAC=1.0 WAS USED IN NEW 50-STATE SIMULATION (IFSTATE=1)
C CSPTURBFAC=1.0 WAS USED IN 145-COUNTRY SIMULATIONS
C
      CSPSTORGAT = 2.61244594
      CSPCHARFAC = CSPTURBFAC * CSPSTORGAT
C
      IF (CSPTURBFAC.GT.CSPCHARFAC) THEN
       WRITE(IOUT,*)'POWERWORLD: CSPTURBFAC>CSPCHARFAC ',CSPTURBFAC,
     1               CSPCHARFAC
       STOP
      ENDIF
C
C ***************************************************************************
C                      INITIALIZE SEVERAL PARAMETERS
C ***************************************************************************
C IONWIND.. = 1..MXCAP INDEX NUMBER CORRESPONDING TO EACH GENERATOR TYPE
C
      IONWIND  = 1
      IOFFWIND = 2
      IRESPV   = 3
      ICOMGVPV = 4
      IUTILPV  = 5
      ICSPSTOR = 6
      ICSPNOST = 7
      IGEOEL   = 8
      IHYDRO   = 9
      ITIDAL   = 10
      IWAVE    = 11
      ISOLTHM  = 12
      IGEOHT   = 13
C
C IY2006   = 1..MXYLOAD YEAR CORRESPONDING TO 2006 (1..MXYLOAD = 2006 TO 2016)
C IY2007   = 1..MXYLOAD YEAR CORRESPONDING TO 2007 (1..MXYLOAD = 2006 TO 2016)
C
C IY2016   = 1..MXYLOAD YEAR CORRESPONDING TO 2016 (1..MXYLOAD = 2016 TO 2019)
C IY2017   = 1..MXYLOAD YEAR CORRESPONDING TO 2017 (1..MXYLOAD = 2016 TO 2019)
C IY2018   = 1..MXYLOAD YEAR CORRESPONDING TO 2018 (1..MXYLOAD = 2016 TO 2019)
C IY2019   = 1..MXYLOAD YEAR CORRESPONDING TO 2019 (1..MXYLOAD = 2016 TO 2019)
C
C USED WHEN IFCONUS=1
C
      IY2006   = 1
      IY2007   = 2
C
C USED WHEN IFSTATES=1
C
      IY2016   = 1
      IY2017   = 2
      IY2018   = 3
      IY2019   = 4
C
C IRESID.. = 1..MXSECTOR INDEX NUMBER CORRESPONDING TO EACH SECTOR
C            RESIDENTIAL, COMMERCIAL, TRANSPORTATION, INDUSTRY,
C            AGRICULTURE/FORESTRY/FISHING, OTHER
C
      IRESID = 1
      ICOMM  = 2
      IIND   = 3
      ITRAN  = 4
      IAGFF  = 5
      IOTH   = 6
C
C IPHS..    = 1..MXSTOR INDEX NUMBER CORRESPONDING TO EACH STORAGE COST
C IPCMCSP   = TO IDENTIFY COST OF PHASE-CHANGE MATERIAL IN ALL CSP
C IMIRCSP   = TO IDENTIFY COST OF MIRRORS FOR ADDITIONAL CSP CAPACITY
C             BEYOND THAT OF RATED STEAM TURBINE POWER
C IHTBAT    = TO IDENTIFY COST OF HEAT BATTERY
```

```
C
      IPHS    = 1
      ICWSTES = 2
      IPCMCSP = 3
      IMIRCSP = 4
      IPCMICE = 5
      IHWSTES = 6
      ILIB    = 7
      IHTBAT  = 8
C
C MXGRIDS   = MAX NUMBER OF GRID REGIONS IN THE WORLD
C PRINFLATE = INFLATES 2020 PRICES TO 2020 DOLLARS
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR H2 ELECTROLYSIS+COMPRESSION OVER SIM
C
      PRINFLATE = 1.000
C
      CSHTMAX   = 0.
      H2CURMAX  = 0.
      H2LDPEAKI = SMAL30
C
      DO I         = 1, MXDAY
       DAYFLEX( I) = 0.
       H2FLEX(  I) = 0.
       TWARMDAY(I) = 0.
       TCOOLDAY(I) = 0.
      ENDDO
C
      DO I      = 1, MXDAY + 1
       IGMTM(I) = 0
       IDYR( I) = 0
      ENDDO
C
      DO I          = 1, MXHRSIM
       REMAINHR( I) = 0.
       NTIMSTEPS(I) = 0
      ENDDO
C
      DO I          = 1, MXYEAR
       NDAYYR(   I) = 0
       NHYEAR(   I) = 0
       NHCUM(    I) = 0
       AMAXLOAD( I) = 0.
       AMINLOAD( I) = 999.
       RAMPMAX(  I) = 0.
       TIMAXRAMP(I) = 0.
       TIMAXLOAD(I) = 0.
       TIMINLOAD(I) = 0.
       AVCOLDLD( I) = SMAL30
       AVHEATLD( I) = SMAL30
       AVWINPOW( I) = 0.
       HRSINYR(  I) = 0.
C
       DO J          = 1, MXMONTH
        LDMONTH(I,J) = 0
       ENDDO
      ENDDO
C
      DO I          = 1, NYEARS
       HDDYR(I)     = 0.
       CDDYR(I)     = 0.
      ENDDO
C
      IF (NYEARS.GT.MXYEAR) THEN
       WRITE(IOUT,*)'POWERWORLD: NYEAR SHOULD BE<=MXYEAR ',NYEARS,MXYEAR
       STOP
      ENDIF
C
C ***************************************************************************
C                     INITIALIZE DATE PARAMETERS
C ***************************************************************************
C INITYEAR = INITIAL YEAR OF SIMULATIONS
C IYEAR    = CURRENT YEAR OF SIMULATION
C NYEARS   = NUMBER OF YEARS OF SIMULATION (1..ANY NUMBER NOW)
C LEAP     = 1 FOR LEAP DAY; 0 IF NO LEAP DAY
C NDAYYR   = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
```

```
C NHYEAR   = NUMBER OF HOURS PER YEAR OF SIMULATION (EITHER 8760 OR 8784)
C LDMONTH  = NUM DAYS IN MONTH (ACCOUNTING FOR LEAP DAYS) FOR EACH YEAR OF SIM
C NDSIM    = TOTAL NUMBER OF DAYS OF MODEL SIMULATION HERE
C MXHPDAY  = NUMBER OF HOURS PER DAY
C
      IGMTD        = 0
      IYEAR        = INITYEAR - 1
C
      NDSIM        = 0
      DO I         = 1, MXYEAR
       IYEAR       = IYEAR + 1
C
       IF (MOD(IYEAR,4).EQ.0) THEN
        LEAP       = 1
       ELSE
        LEAP       = 0
       ENDIF
C
       NDAYYR(I)   = 365 + LEAP
       NHYEAR(I)   = NDAYYR(I) * MXHPDAY
C
       DO K        = 1, MXMONTH
        IF (K.EQ.4.OR.K.EQ.6.OR.K.EQ.9.OR.K.EQ.11) THEN
         LDMONTH(I,K) = 30
        ELSEIF (K.EQ.2) THEN
         LDMONTH(I,K) = 28 + LEAP
        ELSE
         LDMONTH(I,K) = 31
        ENDIF
       ENDDO
C
C IGMTM    = 1..MXMONTH*NYEARS MONTH CORRESPONDING TO EACH GMT DAY OF SIMULATION
C IGMTD    = 1..NDSIM GMT DAY OF SIMULATION PERIOD. 1=JAN 1 OF FIRST YEAR
C NDYEAR   = 1..365 OR 366 GMT DAY OF YEAR FOR EACH 1..NDSIM DAY OF SIM
C IDYR     = 1..365 OR 366 GMT DAY OF YEAR CORRESP TO EACH 1..NDSIM DAY OF SIM
C
C THE NUMBER OF DAYS OF SIMULATION IS DEFINED BY NYEARS
C
       IF (I.LE.NYEARS) THEN
        NDSIM          = NDSIM + NDAYYR(I)
        NDYEAR         = 0
        DO K           = 1, MXMONTH
         DO L          = 1, LDMONTH(I,K)
          IGMTD        = IGMTD  + 1
          NDYEAR       = NDYEAR + 1
          IGMTM(IGMTD) = K + 12 * (I - 1)
          IDYR( IGMTD) = NDYEAR
         ENDDO
        ENDDO
       ENDIF
C
C NHCUM = CUMULATIVE NUMBER OF HOURS OF SIMULATION FROM START TO END
C         OF CURRENT YEAR I=1..NYEARS. THUS, NHCUM(1)=NHYEAR(1),
C         NHCUM(2)=NHYEAR(1) + NHYEAR(2), ETC.
C
       DO J      = 1, I
        NHCUM(I) = NHCUM(I) + NHYEAR(J)
       ENDDO
C
      ENDDO
C     ENDDO I = 1, MXYEAR
C
C THIS IS NEEDED ONLY FOR PRINTING
C
      IGMTM(NDSIM+1)  = IGMTM(NDSIM) + 1
C
C NHRSIM   = TOTAL NUMBER OF HOURS OF MODEL SIMULATION HERE
C NTSSIM   = TOTAL NUMBER OF HIGH-RES (30-S) TIMES STEPS OF SIMULATION
C NTSPERHR = 120 = NUMBER OF 30-SECOND TIMES STEPS PER HR
C
      NHRSIM = NDSIM  * MXHPDAY
      NTSSIM = NHRSIM * NTSPERHR
C
C NDSIM   = TOTAL NUMBER OF DAYS OF MODEL SIMULATION HERE
C DAYSPY  = AVERAGE NUMBER OF DAYS PER YEAR DURING WHOLE SIMULATION
```

```
C HRSPYR  = AVERAGE NUMBER OF HOURS PER YEAR DURING WHOLE SIMULATION
C HRSPDAY = NUMBER OF HOURS PER DAY (24)
C
      DAYSPY = FLOAT(NDSIM  / NYEARS)
      HRSPYR = DAYSPY * HRSPDAY
C
C ***************************************************************************
C                      INITIALIZE OTHER PARAMETERS TO ZERO
C ***************************************************************************
C
      IGRIDUSE    = 0
      IGEUROPE    = 0
      TWHSUPPLY   = 0.
      TWHDEMAND   = 0.
      TWHSHEAT    = 0.
      TWHSCOLD    = 0.
      TWHSHIGHT   = 0.
      TWHEHEAT    = 0.
      TWHECOLD    = 0.
      TWHEHIGHT   = 0.
      TWHSTORH2   = 0.
      TWHELECH2   = 0.
      TWHONWIN    = 0.
      TWHOFFWIN   = 0.
      TWHROOFPV   = 0.
      TWHUTILPV   = 0.
      TWHSTCSP    = 0.
      TWHCSP      = 0.
      TWHGEOEL    = 0.
      TWHHYD      = 0.
      TWHPKHYD    = 0.
      TWHBSHYD    = 0.
      TWHWAV      = 0.
      TWHTID      = 0.
      TWHTHEAT    = 0.
      TWHGEOHT    = 0.
      HRSSIM      = 0.
      H2TCUMTWH   = 0.
      H2ECUMTWH   = 0.
C
      DO I         = 1, MXLOADYR
       TIMLOAD( I) = 0.
       BLOAD(   I) = 0.
       HOTHOUR( I) = 0.
       COLDHOUR(I) = 0.
      ENDDO
C
      DO I            = 1, MXHPYEAR
       READLOAD( I)   = 0.
       DO J           = 1, MXYLOAD
        ALOADHR( I,J) = 0.
        ALOADREG(I,J) = 0.
       ENDDO
       DO J           = 1, MXCOUNTRY
        IFUSED(  J,I) = 0
        STORLOAD(J,I) = 0.
       ENDDO
      ENDDO
C
      DO J            = 1, MXYHRLOAD
       BLOADMW(J)     = 0.
       YLOADHR(J)     = 0.
       IYOFHRLD(J)    = J + IYBEFORE
       DO I           = 1, MXTSPYR
        HRESLOAD(I,J) = 0.
       ENDDO
      ENDDO
C
      DO I            = 1, MXTSHRALL
       DLOAD(  I)     = 0.
       TLOADHR(I)     = 0.
      ENDDO
C
C IYOFLOAD = YEAR (2006 TO 2016) CORRESPONDING TO EACH J=1,MXYLOAD INDEX #
C
```

```
      DO J          = 1, MXYLOAD
       YRLOAD(  J)  = 0.
       ILOADMW( J)  = 0
       IYOFLOAD(J)  = J + IYBEFORE
      ENDDO
C
      DO I          = 1, MXWWS
       IYRWWS(   I) = 0
       TIMORIG(  I) = 0.
       TIMWWS(   I) = 0.
       CURONSH(  I) = 0.
       CUROFFSH( I) = 0.
       CUROOFPV( I) = 0.
       CURUTPV(  I) = 0.
       CURCSP(   I) = 0.
       EXTRACSP( I) = 0.
       CURWAVP(  I) = 0.
       CURHLOAD( I) = 0.
       CURCLOAD( I) = 0.
       CURHFLEX( I) = 0.
       CURCFLEX( I) = 0.
       CURVFLEX( I) = 0.
       CURFLOAD( I) = 0.
       CINFXHLD( I) = 0.
       CINFXCLD( I) = 0.
       CINFXVEH( I) = 0.
       CURGEOP(  I) = 0.
       CURTIDP(  I) = 0.
       CURSOLHT( I) = 0.
       CURGEOH(  I) = 0.
       CURHEAT(  I) = 0.
       CURCOLD(  I) = 0.
       FSTPWARM( I) = 0.
       FSTPCOOL( I) = 0.
       FSTPVEH(  I) = 0.
       CLOAD(    I) = 0.
       DEMAND(   I) = 0.
       SUPPLY(   I) = 0.
       SUPPHT(   I) = 0.
       SUMONWIND(I) = 0.
       SUMOFWIND(I) = 0.
       SUMROOFPV(I) = 0.
       SUMUTILPV(I) = 0.
       SUMCSP(   I) = 0.
       SUMSTHERM(I) = 0.
       SUMHEAT(  I) = 0.
       SUMCOLD(  I) = 0.
       PERHRS(   I) = 0.
      ENDDO
C
      DO I            = 1, MXHPDAY
       DO J           = 1, MXDAY
        HRINFLX( I,J) = 0.
        HRONWIN( I,J) = 0.
        HROFFWD( I,J) = 0.
        HRROOF(  I,J) = 0.
        HRUTPV(  I,J) = 0.
        HRCSP(   I,J) = 0.
        HRSHT(   I,J) = 0.
        HRGHT(   I,J) = 0.
        HRSUPP(  I,J) = 0.
        HRCNT(   I,J) = 0.
        HRFLXLD( I,J) = 0.
        PKSUPE(  I,J) = 0.
        PKDEME(  I,J) = 0.
        TOTSUPP( I,J) = 0.
        TOTDEMD( I,J) = 0.
        HRCOUNT( I,J) = 0.
        ORIGLD(  I,J) = 0.
        HCSTOR(  I,J) = 0.
        HCSTLS(  I,J) = 0.
        HCSTLI(  I,J) = 0.
        PHSTOR(  I,J) = 0.
        PHSTLS(  I,J) = 0.
        PHSTLI(  I,J) = 0.
```

```
        HOSTOR(  I,J) = 0.
        HOSTLS(  I,J) = 0.
        HOSTLI(  I,J) = 0.
        HTSTOR(  I,J) = 0.
        HTSTLS(  I,J) = 0.
        HTSTLI(  I,J) = 0.
        HBSTOR(  I,J) = 0.
        HBSTLS(  I,J) = 0.
        HBSTLI(  I,J) = 0.
        HFSTOR(  I,J) = 0.
        HFSTLS(  I,J) = 0.
        HFSTLI(  I,J) = 0.
        BRSTOR(  I,J) = 0.
        BRSTLS(  I,J) = 0.
        BRSTLI(  I,J) = 0.
        UGSTOR(  I,J) = 0.
        UGSTLS(  I,J) = 0.
        UGSTLI(  I,J) = 0.
        HRTDLS(  I,J) = 0.
        HRSHED(  I,J) = 0.
        HRHYDR(  I,J) = 0.
        HRWAVE(  I,J) = 0.
        HRGEOT(  I,J) = 0.
        HRTIDE(  I,J) = 0.
        H2LOAD(  I,J) = 0.
        H2STOR(  I,J) = 0.
        COLDHR(  I,J) = 0.
        WARMHR(  I,J) = 0.
       ENDDO
      ENDDO
C
      DO I             = 1, MXCAP
       TGWINSTGLB(I)   = 0.
       EGWINSTGLB(I)   = 0.
       SUPGLOB(   I)   = 0.
       GATGLOB(   I)   = 0.
       SUMEN(     I)   = 0.
       SUMNP(     I)   = 0.
       ALLTONEW(  I)   = 0.
       GWFINAL(   I)   = 0.
       GWNEW(     I)   = 0.
      ENDDO
C
      DO J              = 1, MXCOUNHDD
       NAMEREAD( J)     = ' '
       HDDNAT(   J)     = 0.
       CDDNAT(   J)     = 0.
      ENDDO
C
      DO J              = 1, MXCOUNTRY
       ISUSED(   J)     = 0.
       NAMECOUN( J)     = ' '
       NAMEORIG( J)     = ' '
       NAMELOAD( J)     = ' '
       GRIDCOUN( J)     = ' '
       NAMHTREG( J)     = ' '
       MAPCOUN(  J)     = 0
       SUPPALL(  J)     = 0.
       WWSTOT(   J)     = 0.
       EXISTPHSC(J)     = 0.
       EXISOLTHC(J)     = 0.
       AREALKM2C(J)     = 0.
       BAULOADC( J)     = 0.
       BAULCOEC( J)     = 0.
       BAUHEALC( J)     = 0.
       BAUCLIMC( J)     = 0.
       AMORTCURC(J)     = 0.
       AMORT50C( J)     = 0.
       AJOBLOSSC(J)     = 0.
       TCONJOBC( J)     = 0.
       TOPJOBC(  J)     = 0.
       CJOBTDC(  J)     = 0.
       OJOBTDC(  J)     = 0.
       CJOBSTORC(J)     = 0.
       OJOBSTORC(J)     = 0.
```

```
       CAPCOSC(  J)     = 0.
       ANNCOSC(  J)     = 0.
       CO2E2050C( J)    = 0.
       SDTRANLENC(J)    = 0.
       FELBUILD(  J)    = 0.
       FELIND(    J)    = 0.
       ILOADCOUN( J)    = 0
       TGWALLCOUN(J)    = 0.
       TGWADCSPC( J)    = 0.
C
       DO I             = 1, MXJOBCAT
        OPJOBSC(J,I)    = 0.
        CONJOBC(J,I)    = 0.
       ENDDO
C
       DO I             = 1, MXCAP
        TGWINSTALL(J,I) = 0.
        TGWINSTGAT(J,I) = 0.
        EGWINSTALL(J,I) = 0.
        SUP2050(   J,I) = 0.
        ENCOUNTRY( J,I) = 0.
        POWCOUNTRY(J,I) = 0.
       ENDDO
C
       DO I             = 1, MXSECTOR
        TLOADSEC(J,I)   = 0.
        FRCH2SEC(J,I)   = 0.
        FELECSEC(J,I)   = 0.
       ENDDO
C
       DO I             = 1, NDAYDATA
        HDDDAY(J,I)     = 0.
        CDDDAY(J,I)     = 0.
       ENDDO
C
      ENDDO
C     ENDDO MXCOUNTRY
C
      DO K              = 1, MXSECTOR
       TSECALL(   K)    = 0.
       H2SECALL(  K)    = 0.
      ENDDO
C
      NUMGRIDS          = 0
      NCOUNTRY          = 0
      ICUSA             = 0
C
      DO J              = 1, MXGRIDS
       NAMEGRID( J)     = ' '
       NCOUNGRID(J)     = 0
       SUMWWS(   J)     = 0.
       SUMH2REG( J)     = 0.
C
       TGWALLREG(J)     = 0.
       EGWALLREG(J)     = 0.
       SUPALLREG(J)     = 0.
       GATALLREG(J)     = 0.
       REGONWIND(J)     = 0.
       REGOFWIND(J)     = 0.
       REGROOFPV(J)     = 0.
       REGUTILPV(J)     = 0.
       REGCSP(   J)     = 0.
       REGSTHERM(J)     = 0.
       REGHEAT(  J)     = 0.
       REGCOLD(  J)     = 0.
       EXISTPHSR(J)     = 0.
       EXISOLTHR(J)     = 0.
       AREALKM2R(J)     = 0.
       BAULOADR( J)     = 0.
       BAULCOER( J)     = 0.
       BAUHEALR( J)     = 0.
       BAUCLIMR( J)     = 0.
       AMORTCURR(J)     = 0.
       AMORT50R( J)     = 0.
       AJOBLOSSR(J)     = 0.
```

```
       CO2E2050R(J)    = 0.
       SDTRANLENR(J)   = 0.
       AVGCDD(    J)   = 0.
       AVGHDD(    J)   = 0.
       TGWADCSPR( J)   = 0.
C
       DO I             = 1, MXJOBCAT
        OPJOBSR(J,I)    = 0.
        CONJOBR(J,I)    = 0.
       ENDDO
C
       DO K            = 1, MXSECTOR
        TLOADSUM( J,K) = SMAL30
        H2SECGRID(J,K) = 0.
        FRCH2REG( J,K) = 0.
        ELLOADSEC(J,K) = 0.
        FELECREG( J,K) = 0.
       ENDDO
C
       DO I            = 1, MXCOUNTRY
        NAMORIGGR(J,I) = ' '
        NAMCOUNGR(J,I) = ' '
        NUMCOUNGR(J,I) = 0
       ENDDO
C
       DO K             = 1, MXCAP
        TGWINSTREG(J,K) = SMAL30
        EGWINSTREG(J,K) = 0.
        TGWGATREG( J,K) = 0.
        SUPGWREG(  J,K) = 0.
        FLOADREG(  J,K) = 0.
       ENDDO
C
       DO N              = 1, NYEARS
        DO I             = 1, MXDAYYR
         HDDREG(J,N,I)   = 0.
         CDDREG(J,N,I)   = 0.
        ENDDO
       ENDDO
C
      ENDDO
C     ENDDO J = 1, MXGRIDS

       DO N              = 1, NYEARS
        DO I             = 1, MXDAYYR
         FRDAYCOOL(N,I)  = 0.
         FRDAYWARM(N,I)  = 0.
        ENDDO
       ENDDO
C
      DO J           = 1, MXREGUS
       DO I          = 1, MXHLOADUS
        USALOAD(I,J) = 0
       ENDDO
      ENDDO
C
C ***************************************************************************
C                                OPEN FILES
C ***************************************************************************
C                                INPUT FILES
C ***************************************************************************
C countrystat.dat = COUNTRY LIST, REGION OF EACH COUNTRY, AGGREGATE LOAD
C                   DATA BY SECTOR, NEW+EXISTING & EXISTING INSTALLATIONS
C                   OF WWS AND OTHER DATA FROM
C                   'Table for GATOR-GCMOM' TAB IN THE AllCountries.xlsx FILE
C heatfrac.dat    = FRACTION OF TOTAL HEAT+ELEC FINAL ENERGY RESID/COMM/GOV
C                   BUILDINGS THAT IS FOR LOW-TEMP HEAT PROCESSES AND FRACTION
C                   OF TOTAL HEAT+ELEC IN INDUSTRY FOR HIGH TEMPERATURE HEAT
C                   NUMBERS ARE GIVEN BY COUNTRY
C heatcooldd.dat  = NUMBER OF HEATING AND COOLING DEGREE DAYS (HDD, CDD)
C                   BY COUNTRY AND DAY OF YEAR.
C                   BizEE (2015) Custom degree day data, http://www.degreedays.net
C wwssupconus.dat = INSTANTANEOUS AND CUMULATIVE WIND AND SOLAR PREDICTIONS FROM
C                   GATOR-GCMOM FOR 48 CONTIGUOUS UNITED STATES
C                   THIS IS OBTAINED WHEN IGLOBFARMS = 0 IN GATOR-GCMOM
```

```
C wwssupworld.dat = INSTANTANEOUS AND CUMULATIVE WIND AND SOLAR PREDICTIONS FROM
C                   GATOR-GCMOM FOR 143 COUNTRIES
C IFREWRITE       = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                    KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                    AND ELIMINATING AVERAGE VALUES (KEEPING INSTANT VALUES
C                    ONLY) WHEN THIS IS COMPLETE, USE KWW2 FILE AS INPUT FOR
C                    IFREWRITE=2. APPLIES WHEN IFCONUS=1 OR 0
C                    AFTER FINISHINING IFREWRITE=1, CAN ERASE KWWS
C                    (wwssupworld.dat)
C
C                     --> IF WANT TO INTERPOLATE SOLAR OR ADD TILT FACTORS,
C                     RUN SOLARTILT/tilt.f, BUT ADJUST SOLAR FOR TILTING ONLY
C                     FOR OLD FILES SINCE GATOR-GCMOM NOW INCLUDES TILTING.
C                     APPLIES ONLY TO IFCONUS=0
C                     --> MOVE OUTPUT FILE FROM tilt.f (wwstilt.dat) to
C                     wwssupreform.dat
C                  = 2: READS KWW2 (wwssupreform.dat),
C                      SUMS VALUES EACH TIME STEP AMONG ALL COUNTRIES IN GRID
C                      REGION GRIDUSE, REWRITES SUMMED VALUES TO A SMALLER
C                      FILE KWW3 (wwssupworld.REGION) (FOR EACH REGION
C                      ALSO CALCULATES CAPACITY FACTOR (CF) OF ONSHORE,
C                      OFFSHORE WIND; ROOFTOP & UTILITY PV AND CSP FROM GATOR-GCMOM
C                      SIMULATiONS BY COUNTRY.
C                  = 3: APPLIES ONLY WHEN IFCONUS=0:
C                       READ DATA FROM FILE wwssupworld.REGION RATHER THAN
C                       wwssupworld.dat FOR ONE GRID REGION.
C                       FILE KWW3 CONTAINS ONLY ONE LINE OF DATA FOR EACH TIME STEP,
C                       WHICH ARE DATA SUMMED OVER ALL COUNTRIES IN REGION GRIDUSE
C                  = 0: READ AND PROCESS FILE KWWS
C                       APPLIES WHEN IFCONUS=1 OR 0
C                       (WHEN IFCONUS=0, READS ALL-COUNTRY DATA)
C
      IF (IFCONUS.EQ.1) THEN
C
       IF (IFREWRITE.EQ.0) THEN
        OPEN(KWWS, FILE = PATHHOME//'READSUPPLY/wwssupconus.dat')
       ELSEIF (IFREWRITE.EQ.1) THEN
        OPEN(KWWS, FILE = PATHTEMP//'wwssupconus.dat')
       ENDIF
C
      ELSE
       OPEN(KDAT, FILE = PATHHOME//'countrystats.dat')
       OPEN(KHTE, FILE = PATHHOME//'heatfrac.dat')
       OPEN(KHDD, FILE = PATHHOME//'heatcooldd.dat')
C
C INPUT SUPPLY DATA
C
       IF (IFREWRITE.EQ.3) THEN
        OPEN(KWWS, FILE = PATHHOME//'READSUPPLY/wwssupworld.'//GRIDUSE)
       ELSEIF (IFREWRITE.EQ.2) THEN
        OPEN(KWWS, FILE = PATHTEM1//'wwssupreform.dat')
       ELSEIF (IFREWRITE.EQ.1.OR.IFREWRITE.EQ.0) THEN
        OPEN(KWWS, FILE = PATHTEMP//'wwssupworld.dat')
       ENDIF
      ENDIF
C
C ***************************************************************************
C                              OUTPUT FILES
C ***************************************************************************
C countrydata.out  = OUTPUT FILE SUMMARY OF COUNTRY DATA FROM countrystat.dat
C                    AFTER SOME PROCESSING
C wwsmonthly.out   = OUTPUT FILE FOR MONTHLY-TOTAL STATISTICS
C wwshourly.out    = OUTPUT FILE FOR HOURLY-TOTAL STATISTICS
C wwssupreform.dat = INSTANTANEOUS AND CUMULATIVE WIND AND SOLAR PREDICTIONS FROM
C                    GATOR-GCMOM REWRITTEN FROM wwssupply.dat IF REDUNDANT TIMES
C IFREWRITE        = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                       KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                       AND ELIM AVERAGE VALUES (KEEPING INSTANT VALUES ONLY)
C                       WHEN THIS IS COMPLETE, USE KWW2 AS INPUT FOR IFREWRITE=2
C                       APPLIES WHEN IFCONUS=0. WHEN IFCONUS=1, READ
C                       wwssupconus.dat FROM PATHTEMP AND WRITE TO PATHHOME
C
      IF (IFCONUS.EQ.0) THEN
       OPEN(KOUT, FILE = PATHHOME//'countrydata.out')
       IF (IFREWRITE.EQ.1) THEN
```

```
        OPEN(KWW2, FILE = PATHTEM1//'wwssupreform.dat')
       ENDIF
      ELSE
       IF (IFREWRITE.EQ.1) THEN
        OPEN(KWW2, FILE = PATHHOME//'wwssupconus.dat')
       ENDIF
      ENDIF
C
      OPEN(IMON, FILE = PATHHOME//'wwsmonthly.'//GRIDUSE)
      OPEN(IHOU, FILE = PATHHOME//'wwshourly.'//GRIDUSE)
      OPEN(KHPK, FILE = PATHHOME//'pkflex.'//GRIDUSE)
C
C ***************************************************************************
C          READ AND PROCESS COUNTRY DATA IN COUNTRYSTAT.DAT FROM
C       'Table for GATOR-GCMOM' TAB IN THE AllCountries.xlsx FILE
C ***************************************************************************
C IFCONUS = 1: SOLVE GRID INTEGRATION OVER 48 CONTIGUOUS UNITED STATES (CONUS)
C              AGGREGATE CONUS DATA ARE SPECIFIED WITHIN THIS PROGRAM
C              OBTAINED FROM 50-STATE 50-state-WWS.xlsx FILE
C         = 0: SOLVE GRID INTEGRATION OVER REGION OF THE WORLD GRIDUSE,
C              WHERE COUNTRIES TREATED IN EACH GRID REGION AND THEIR
C              CHARACTERISTICS ARE DEFINED IN countrystats.dat, WHICH IS
C              OBTAINED FROM 'Table for GATOR-GCMOM' TAB IN Allcountries.xlsx
C
      IF (IFCONUS.EQ.0) THEN
       READ(KDAT,*)
       READ(KDAT,*)
       READ(KDAT,*)
C
C COUNTRY    = COUNTRY NAME
C GRIDNAM    = NAME OF GRID REGION IN WHICH COUNTRY LIES
C TMWONWIND  = NEW+EXISTING INSTALLED MW OF ONSHORE WIND TURBINES
C TMWOFFWIND = NEW+EXISTING INSTALLED MW OF OFFSHORE WIND TURBINES
C TMWRESPV   = NEW+EXISTING INSTALLED MW OF RESIDENTIAL ROOFTOP PV
C TMWCOMPV   = NEW+EXISTING INSTALLED MW OF COMMERCIAL/GOVERNMENT ROOFTOP PV
C TMWUTILPV  = NEW+EXISTING INSTALLED MW OF UTILITY-SCALE PV
C TMWCSPORIG = NEW+EXISTING INSTALLED MW OF CONCENTRATED SOLAR POWER (CSP)
C              THIS IS MODIFIED HERE BY CSPTURBFAC
C TMWCSPADD  = ESTIMATED NEW INSTALLED MW OF CSP NEEDED FOR STORAGE
C TMWGEOEL   = NEW+EXISTING INSTALLED MW OF GEOTHERMAL FOR ELECTRIC POWER
C TMWHYD     = NEW+EXISTING INSTALLED MW OF HYDROELECTRIC POWER
C TMWWAVE    = NEW+EXISTING INSTALLED MW OF WAVE POWER
C TMWTIDAL   = NEW+EXISTING INSTALLED MW OF TIDAL POWER
C TMWSOLTH   = NEW+EXISTING INSTALLED MW OF SOLAR THERMAL FOR HEAT
C TMWGEOHT   = NEW+EXISTING INSTALLED MW OF GEOTHERMAL FOR HEAT
C TMWONWGAT  = NEW+EXISTING INSTALLED MW ONSHORE WIND USED IN GATOR-GCMOM SIMS
C            = TMWONWIND UNLESS TMWONWIND HAS BEEN UPDATE SINCE SIMS BEGAN
C TMWOFFWGAT = NEW+EXISTING INSTALLED MW OFFSHORE WIND IN GATOR-GCMOM SIMS
C TMWRESGAT  = NEW+EXISTING INSTALLED MW RES ROOF PV IN GATOR-GCMOM SIMS
C TMWCOMGAT  = NEW+EXISTING INSTALLED MW COM/GOV ROOF PV IN GATOR-GCMOM SIMS
C TMWUTILGAT = NEW+EXISTING INSTALLED MW UTILITY PV IN GATOR-GCMOM SIMS
C TMWCSPOGAT = NEW+EXISTING INSTALLED MW ORIG UTILITY CSP IN GATOR-GCMOM SIMS
C TMWCSPAGAT = NEW INSTALLED MW ADDED UTILITY CSP FOR STORAGE IN GATOR-GCMOM SIMS
C TMWSTHGAT  = NEW INSTALLED MW ADDED SOLAR THERMAL FOR HEAT IN GATOR-GCMOM SIMS
C EMWONWIND  = 2014 EXISTING INSTALLED MW OF ONSHORE WIND TURBINES
C EMWOFFWIND = 2014 EXISTING INSTALLED MW OF OFFSHORE WIND TURBINES
C EMWRESPV   = 2014 EXISTING INSTALLED MW OF RESIDENTIAL PV
C EMWCOMPV   = 2014 EXISTING INSTALLED MW OF COMMERCIAL/GOVERNMENT PV
C EMWUTILPV  = 2014 EXISTING INSTALLED MW OF UTILITY-SCALE PV
C EMWCSP     = 2014 EXISTING INSTALLED MW OF CSP
C EMWGEOEL   = 2014 EXISTING INSTALLED MW OF GEOTHERMAL FOR ELECTRICITY
C EMWHYD     = 2014 EXISTING INSTALLED MW OF HYDROELECTRIC POWER
C EMWWAVE    = 2014 EXISTING INSTALLED MW OF WAVE POWER
C EMWTIDAL   = 2014 EXISTING INSTALLED MW OF TIDAL POWER
C EMWGEOHT   = 2014 EXISTING INSTALLED MW GEOTHERMAL HEAT COLLECTORS
C SUPALL2050 = 2050 TOTAL POWER SUPPLY (GW) ALL ELEC POW SOURCES (NOT SUPGHT2050)
C SUPONW2050 = 2050 ONSHORE WIND DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPOFW2050 = 2050 OFFSHORE WIND DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPRPV2050 = 2050 RESIDENTIAL ROOF PV DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPCPV2050 = 2050 COMM/GOVT ROOF PV DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPUPV2050 = 2050 UTILITY PV DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPCSP2050 = 2050 CSP DELIVERED ELEC POWER AFTER T&D LOSSES (GW)
C SUPGEL2050 = 2050 GEOTHERMAL DELIV ELEC POWER AFTER T&D LOSSES (GW)
C SUPHYD2050 = 2050 HYDROELECTRIC DELIVERED POWER AFTER T&D LOSSES (GW)
C SUPTID2050 = 2050 TIDAL DELIVERED POWER AFTER T&D LOSSES (GW)
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C SUPWAV2050 = 2050 WAVE DELIVERED POWER AFTER T&D LOSSES(GW)
C SUPGHT2050 = 2050 GEOTHERMAL FOR HEAT DELIV ELEC POWER AFTER T&D LOSSES (GW)
C TLOADTOT   = 2050 ALL-PURPOSE END-USE LOAD (GW) SHOULD = SUPALL2050
C BLOADRES   = 2050 RESIDENTIAL      WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADCOM   = 2050 COMMERCIAL       WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADIND   = 2050 INDUSTRIAL       WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADTRA   = 2050 TRANSPORTATION   WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADAGF   = 2050 AG/FORESTRY/FISH WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADOTH   = 2050 OTHER            WWS LOAD (GW) AFTER HEAT PUMPS
C FRACREH2   = FRACT RESIDENTIAL ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACCOH2   = FRACT COMMERCIAL ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACINH2   = FRACT INDUSTRY ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACTRH2   = FRACT TRANSPORT ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACAFH2   = FRACT AG/FOREST/FISHING ELEC GOING TO H2 ELECTROL/COMPRESS/STORAGE
C FRACOTH2   = FRACT OTHER ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C EXISTPHS   = EXISTING PUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (GW)
C              IN COUNTRY
C EXISOLTHM  = EXISTING SOLAR THERMAL FOR HEAT NAMEPLATE CAPACITY (GW) IN COUNTRY
C              THIS IS USUALLY USED FOR HEATING WATER
C AREALAND   = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF COUNTRY
C BAULOADGW  = 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOE1   = 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALTH  = 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C              COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C              MORTALITY NUMBERS AMORT50F AND AMOTCURF NOT REDUCED
C BAUCLIMATE = 2050 BAU CLIMATE COST ($2013 CENTS/KWH-ALL-ENERGY)
C AMORTCURF  = 2016 AIR POLLUTION MORTALITY BY COUNTRY FROM WHO READ IN
C AMORT50F   = 2050 AIR POLLUTION MORTALITY BY COUNTRY READ IN FROM FILE
C              COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C              MORTALITY NUMBERS AMORT50F, AMOTCURF INCLUDE ALL AIR POL DEATHS
C FELECRES   = FRAC 2050 END-USE HEAT+ELEC RESIDE SECTOR GOING TO ELEC. REST HEAT
C FELECCOM   = FRAC 2050 END-USE HEAT+ELEC COMMER SECTOR GOING TO ELEC. REST HEAT
C FELECIND   = FRAC 2050 END-USE HEAT+ELEC INDUST SECTOR GOING TO ELEC. REST HEAT
C FELECTRA   = FRAC 2050 END-USE HEAT+ELEC TRANSP SECTOR GOING TO ELEC. REST HEAT
C FELECAGF   = FRAC 2050 END-USE HEAT+ELEC AG/F/F SECTOR GOING TO ELEC. REST HEAT
C FELECOTH   = FRAC 2050 END-USE HEAT+ELEC OTHER  SECTOR GOING TO ELEC. REST HEAT
C AJOBLOSSI  = JOB LOSS IN COUNTRY, AS CALCULATED FROM SPREADSHEET
C OPJOBSI    = LONG-TERM, FULL-TIME OPERATIONAL JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. ADJUST HERE SO FOR NEW+EXISTING
C              AND BASED ON UPDATED NAMEPLATE CAPACITIES
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CONJOBSI   = LONG-TERM, FULL-TIME CONSTRUCTION JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. KEEP BASED ON NEW NAMEPLATE.
C              ADJUST HERE ONLY FOR NAMEPLATE CAPACITY.
C              THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C TONNECO2E  = COUNTRY TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C SDTRANSMIS = ADDITIONAL (BEYOND BAU) AC/HVAC TRANSMISSION LINES (KM)
C              NEEDED FOR ANNUAL AVERAGE POWER (DOES NOT INCLUD HVDC,
C              WHICH IS ESTIMATED SEPARATELY). USE TO CALCULATE CAPITAL
C              COST OF NON-HVDC TRANSMISSION. ANNUAL COST AND JOBS
C              ALREADY ACCOUNTED FOR.
C
 113   CONTINUE
C
       READ(KDAT,*,END=115) COUNTRY, GRIDNAM,
     1      TMWONWIND,  TMWOFFWIND, TMWWAVE,    TMWGEOEL,   TMWHYD,
     1      TMWTIDAL,   TMWRESPV,   TMWCOMPV,   TMWUTILPV,  TMWCSPORIG,
     1      TMWCSPADD,  TMWSOLTH,   TMWGEOHT,
     1      TMWONWGAT,  TMWOFFWGAT, TMWRESGAT,  TMWCOMGAT,  TMWUTILGAT,
     1      TMWCSPOGAT, TMWCSPAGAT, TMWSTHGAT,
     1      EMWONWIND,  EMWOFFWIND, EMWRESPV,   EMWCOMPV,   EMWUTILPV,
     1      EMWCSP,     EMWGEOEL,   EMWHYD,     EMWWAVE,
     1      EMWTIDAL,   EMWGEOHT,
     1      SUPALL2050, SUPONW2050, SUPOFW2050, SUPRPV2050, SUPCPV2050,
     1      SUPUPV2050, SUPCSP2050, SUPGEL2050, SUPHYD2050, SUPTID2050,
     1      SUPWAV2050, SUPGHT2050,
     1      TLOADTOT,   BLOADRES,   BLOADCOM,   BLOADIND,   BLOADTRA,
     1      BLOADAGF,   BLOADOTH,
     1      FRACREH2,   FRACCOH2,   FRACINH2,   FRACTRH2,   FRACAFH2,
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     1      FRACOTH2,   EXISTPHS,   EXISOLTHM,  AREALAND,
     1      BAULOADGW,  BAULCOE1,   BAUHEALTH,  BAUCLIMATE,
     1      AMORTCURF,  AMORT50F,   AJOBLOSSI,
     1      (OPJOBSI(I),I=1,MXJOBCAT), (CONJOBI(I),I=1,MXJOBCAT),
     1      TONNECO2E,  SDTRANSMIS
C
C NCOUNTRY  = NUMBER OF COUNTRIES READ IN DATASET
C MXCOUNTRY = MAX NUMBER OF COUNTRIES READ IN
C
       NCOUNTRY  = NCOUNTRY + 1
C
       IF (NCOUNTRY.GT.MXCOUNTRY) THEN
        WRITE(IOUT,*) 'POWERWORLD:NCOUNTRY>MXCOUNTY ',NCOUNTRY,MXCOUNTRY
        STOP
       ENDIF
C
C NAMEORIG = NAME OF 1..NCOUNTRY AS READ FROM countrystats.dat
C            THIS NAME IS CHANGED BELOW TO MATCH THOSE FROM wwssupworld.dat
C
       NAMEORIG(NCOUNTRY) = COUNTRY
C
C COUNTRY    = NAME OF CURRENT COUNTRY
C
       IF (COUNTRY.EQ.'BRUNEI-DARUSSA') COUNTRY = 'BRUNEI DARUSSA'
       IF (COUNTRY.EQ.'CONGO-DEMOCRAT') COUNTRY = 'CONGO, DEMOCRA'
       IF (COUNTRY.EQ.'COSTA-RICA')     COUNTRY = 'COSTA RICA    '
       IF (COUNTRY.EQ.'IVORY-COAST')    COUNTRY = 'IVORY COAST   '
       IF (COUNTRY.EQ.'CZECH-REPUBLIC') COUNTRY = 'CZECH REPUBLIC'
       IF (COUNTRY.EQ.'DOMINICAN-REPU') COUNTRY = 'DOMINICAN REPU'
       IF (COUNTRY.EQ.'EL-SALVADOR')    COUNTRY = 'EL SALVADOR   '
       IF (COUNTRY.EQ.'EQUATORIAL-GUI') COUNTRY = 'EQUATORIAL GUI'
       IF (COUNTRY.EQ.'HONG-KONG')      COUNTRY = 'HONG KONG     '
       IF (COUNTRY.EQ.'KOREA-DEM.-PEO') COUNTRY = 'KOREA, DEM. PE'
       IF (COUNTRY.EQ.'KYRGYZ-REPUBLI') COUNTRY = 'KYRGYZ REPUBLI'
       IF (COUNTRY.EQ.'LAO-PDR')        COUNTRY = 'LAOS PDR      '
       IF (COUNTRY.EQ.'LIBYAN-ARAB-JA') COUNTRY = 'LIBYAN ARAB JA'
       IF (COUNTRY.EQ.'MOLDOVA-REPUBL') COUNTRY = 'MOLDOVA REPUBL'
       IF (COUNTRY.EQ.'MACEDONIA-FORM') COUNTRY = 'MACEDONIA     '
       IF (COUNTRY.EQ.'MOROCCO-(INC-W') COUNTRY = 'MOROCCO (INC W'
       IF (COUNTRY.EQ.'ESWATINI-KINGD') COUNTRY = 'SWAZILAND     '
       IF (COUNTRY.EQ.'NEW-ZEALAND')    COUNTRY = 'NEW ZEALAND   '
       IF (COUNTRY.EQ.'SAUDI-ARABIA')   COUNTRY = 'SAUDI ARABIA  '
       IF (COUNTRY.EQ.'CURACAO')        COUNTRY = 'DUTCH ANTILLES'
C
C CHANGE SERBIA HERE SINCE IT WILL REPRESENT SERBIA+MONENEGRO+KOSOVO
C   SINCE ONLY THE COMBINATION OF ALL 3 IS TREATED IN GATOR-GCMOM
C
       IF (COUNTRY.EQ.'SERBIA')         COUNTRY = 'SERBIA AND MON'
       IF (COUNTRY.EQ.'SOUTH-AFRICA')   COUNTRY = 'SOUTH AFRICA  '
       IF (COUNTRY.EQ.'SRI-LANKA')      COUNTRY = 'SRI LANKA     '
       IF (COUNTRY.EQ.'SYRIAN-ARAB-RE') COUNTRY = 'SYRIAN ARAB RE'
       IF (COUNTRY.EQ.'TRINIDAD-AND-T') COUNTRY = 'TRINIDAD AND T'
       IF (COUNTRY.EQ.'UNITED-ARAB-EM') COUNTRY = 'UNITED ARAB EM'
       IF (COUNTRY.EQ.'UNITED-KINGDOM') COUNTRY = 'UNITED KINGDOM'
C
C ICUSA = 1..NCOUNTRY INDEX CORRESPONDING TO U.S.A.
C
       IF (COUNTRY.EQ.'UNITED-STATES-') THEN
                                        COUNTRY = 'UNITED STATES '
                                        ICUSA   = NCOUNTRY
       ENDIF
C
C NAMECOUN   = FINAL NAME OF EACH 1..NCOUNTRY COUNTRY
C              NAMECOUN NAMES MATCH COUNTRY NAMES FROM wwssupworld.dat
C GRIDCOUN   = NAME OF EACH 1..NCOUNTRY GRID REGION THE COUNTRY LIES IN
C
       NAMECOUN(NCOUNTRY) = COUNTRY
       GRIDCOUN(NCOUNTRY) = GRIDNAM
C
C NUMGRIDS  = NUMBER OF GRID REGIONS IN DATASET
C NAMEGRID  = NAME OF EACH 1..NUMGRIDS GRID REGION
C NCOUNGRID = NUMBER OF COUNTRIES IN EACH 1..NUMGRIDS GRID REGION
C MXGRIDS   = MAX NUMBER OF GRID REGIONS IN THE WORLD
C
       DO J    = 1, NUMGRIDS
```

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       IF (GRIDNAM.EQ.NAMEGRID(J)) GOTO 110
      ENDDO
C
      NUMGRIDS  = NUMGRIDS + 1
      J         = NUMGRIDS
C
      IF (J.GT.MXGRIDS) THEN
       WRITE(IOUT,*) 'POWERWORLD: NUMGRIDS>MXGRIDS ',J,MXGRIDS
       STOP
      ENDIF
C
      NAMEGRID(J) = GRIDNAM
C
C ***************************************************************************
C    OPEN A FILE FOR EACH GRID REGION TO WRITE WWS DATA FROM GATOR-GCMOM,
C               SUMMED OVER ALL COUNTRIES IN GRID REGION, TO
C ***************************************************************************
C IFREWRITE     = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                    KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                    AND ELIMINATING AVERAGE VALUES (KEEPING INSTANT VALUES ONLY)
C                    WHEN THIS IS COMPLETE, USE KWW2 FILE AS INPUT FOR IFREWRITE=2
C                    APPLIES WHEN IFCONUS=0. WHEN IFCONUS=1, READ
C                    wwssupconus.dat FROM PATHTEMP AND WRITE TO PATHHOME
C                    AFTER FINISHINING IFREWRITE=1, CAN ERASE wwssupworld.dat
C               = 2: BEFORE RUNNING WITH IFREWRITE=2, RUN tilt.f TO SMOOTH SOLAR
C                    APPLIES ONLY WHEN IFCONUS=0: READ KWW2 (wwssupreform.dat),
C                    SUM VALUES EACH TIME STEP AMONG ALL COUNTRIES IN GRID
C                    REGION GRIDUSE, REWRITE SUMMED VALUES TO A SMALLER FILE
C                    KWW3 (wwssupworld.REGION) (FOR EACH REGION
C                    ALSO CALCULATE CAPACITY FACTOR (CF) OF ONSHORE, OFFSHORE WIND;
C                    ROOFTOP & UTILITY PV AND CSP FROM GATOR-GCMOM SIMULATIONS
C                    BY COUNTRY.
C wwsworld.GRIDUSE = SAME AS wwssupworld, BUT WITH DATA FOR EACH COUNTRY IN
C                    GRID REGION IGRIDUSE SUMMED EACH TIME STEP INTO ONE
C                    AGGREGATE VALUE FOR EACH ENERGY SOURCE (E.G., ONSHORE WIND)
C
C CODE COMES THROUGH HERE ONCE FOR EACH COUNTRY
C
      IF (IFREWRITE.EQ.2) THEN
       OPEN(KWW3+J-1,FILE=PATHHOME//'READSUPPLY/wwssupworld.'//GRIDNAM)
      ENDIF
C
C IGRIDUSE  = 1..NUMGRIDS INDEX NUMBER CORRESPONDING TO GRID BEING USED.
C IGEUROPE  = 1..NUMGRIDS INDEX NUMBER CORRESPONDING TO 'EUROPE'
C NCOUNGRID = NUMBER OF COUNTRIES IN EACH 1..NUMGRIDS GRID REGION
C
      IF (GRIDNAM.EQ.GRIDUSE)  IGRIDUSE = J
      IF (GRIDNAM.EQ.'EUROPE') IGEUROPE = J
C
 110  NCOUNGRID(J) = NCOUNGRID(J) + 1
      NC           = NCOUNGRID(J)
C
      IF (NC.GT.MXCOUNTRY) THEN
       WRITE(IOUT,*) 'POWERWORLD: NCOUNGRID>MXCOUNTY ',NC,MXCOUNTRY
       STOP
      ENDIF
C
C NAMORIGGR = ORIG COUNTRY NAME OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C NAMCOUNGR = FINAL COUNTRY NAME OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C NUMCOUNGR = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C
      NAMORIGGR(J,NC) = NAMEORIG(NCOUNTRY)
      NAMCOUNGR(J,NC) = NAMECOUN(NCOUNTRY)
      NUMCOUNGR(J,NC) = NCOUNTRY
C
C TGWINSTALL = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY IN 2050
C              FOR CSP, NO NEED TO ADD TMWCSPADD TO TGWINSTALL HERE
C              SINCE THE ADDITIONAL CSP IS ADDED LATER WITH CSPTURBFAC
C GWPERMW    = GIGAWATTS (GW) PER MEGAWATT(MW)
C TGWADCSPC  = ADDED CSP TURBINES (GW) IN STATE/COUNTRY FROM SPREADSHEET TO
C              MEET CONTINUOUS LOAD. USED ONLY TO CALCULATE JOB NUMBERS
C              NEW SPREADSHEETS SHOULD HAVE 0 VALUES
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C              OLD SPREADSHEET VALUES WERE TWMCSPORIG*0.6
C
       TGWINSTALL(NCOUNTRY,IONWIND)  = GWPERMW * TMWONWIND
       TGWINSTALL(NCOUNTRY,IOFFWIND) = GWPERMW * TMWOFFWIND
       TGWINSTALL(NCOUNTRY,IRESPV)   = GWPERMW * TMWRESPV
       TGWINSTALL(NCOUNTRY,ICOMGVPV) = GWPERMW * TMWCOMPV
       TGWINSTALL(NCOUNTRY,IUTILPV)  = GWPERMW * TMWUTILPV
C      TGWINSTALL(NCOUNTRY,ICSPSTOR) = GWPERMW * (TMWCSPORIG+TMWCSPADD)
       TGWINSTALL(NCOUNTRY,ICSPSTOR) = GWPERMW * TMWCSPORIG
       TGWADCSPC( NCOUNTRY)          = GWPERMW * TMWCCSPADD
       TGWINSTALL(NCOUNTRY,IGEOEL)   = GWPERMW * TMWGEOEL
       TGWINSTALL(NCOUNTRY,IHYDRO)   = GWPERMW * TMWHYD
       TGWINSTALL(NCOUNTRY,ITIDAL)   = GWPERMW * TMWTIDAL
       TGWINSTALL(NCOUNTRY,IWAVE)    = GWPERMW * TMWWAVE
       TGWINSTALL(NCOUNTRY,ISOLTHM)  = GWPERMW * TMWSOLTH
       TGWINSTALL(NCOUNTRY,IGEOHT)   = GWPERMW * TMWGEOHT
C
C TGWINSTGAT = NEW+EXIST INSTALLED MW 1..MXCAP DEVICE BY COUNTRY GATOR-GCMOM SIMS
C              FOR CSP, NEED TO ADD TMWCSPAGAT HERE.
C
       TGWINSTGAT(NCOUNTRY,IONWIND)  = GWPERMW * TMWONWGAT
       TGWINSTGAT(NCOUNTRY,IOFFWIND) = GWPERMW * TMWOFFWGAT
       TGWINSTGAT(NCOUNTRY,IRESPV)   = GWPERMW * TMWRESGAT
       TGWINSTGAT(NCOUNTRY,ICOMGVPV) = GWPERMW * TMWCOMGAT
       TGWINSTGAT(NCOUNTRY,IUTILPV)  = GWPERMW * TMWUTILGAT
       TGWINSTGAT(NCOUNTRY,ICSPSTOR) = GWPERMW * (TMWCSPOGAT+TMWCSPAGAT)
       TGWINSTGAT(NCOUNTRY,ISOLTHM)  = GWPERMW * TMWSTHGAT
C
C EGWINSTALL = EXISTING INSTALLED GW OF EACH 1..MXCAP DEVICE
C EXISOLTHM  = EXISTING SOLAR THERMAL NAMEPLATE CAPACITY (GW) IN COUNTRY
C              THIS IS USUALLY USED FOR HEATING WATER
C
       EGWINSTALL(NCOUNTRY,IONWIND)  = GWPERMW * EMWONWIND
       EGWINSTALL(NCOUNTRY,IOFFWIND) = GWPERMW * EMWOFFWIND
       EGWINSTALL(NCOUNTRY,IRESPV)   = GWPERMW * EMWRESPV
       EGWINSTALL(NCOUNTRY,ICOMGVPV) = GWPERMW * EMWCOMPV
       EGWINSTALL(NCOUNTRY,IUTILPV)  = GWPERMW * EMWUTILPV
       EGWINSTALL(NCOUNTRY,ICSPSTOR) = GWPERMW * EMWCSP
       EGWINSTALL(NCOUNTRY,IGEOEL)   = GWPERMW * EMWGEOEL
       EGWINSTALL(NCOUNTRY,IHYDRO)   = GWPERMW * EMWHYD
       EGWINSTALL(NCOUNTRY,ITIDAL)   = GWPERMW * EMWTIDAL
       EGWINSTALL(NCOUNTRY,IWAVE)    = GWPERMW * EMWWAVE
       EGWINSTALL(NCOUNTRY,ISOLTHM)  =           EXISOLTHM
       EGWINSTALL(NCOUNTRY,IGEOHT)   = GWPERMW * EMWGEOHT
C
C SUPALL     = 2050 TOTAL POWER SUPPLY (GW) ALL ELEC POW SOURCES (NOT SUPGHT2050)
C SUP2050    = 2050 ELECTRIC POWER (NOT HEAT) SUPPLY (GW) BY 1..MXCAP DEVICE
C
       SUPPALL(NCOUNTRY)             = SUPALL2050
       SUP2050(NCOUNTRY,IONWIND)     = SUPONW2050
       SUP2050(NCOUNTRY,IOFFWIND)    = SUPOFW2050
       SUP2050(NCOUNTRY,IRESPV)      = SUPRPV2050
       SUP2050(NCOUNTRY,ICOMGVPV)    = SUPCPV2050
       SUP2050(NCOUNTRY,IUTILPV)     = SUPUPV2050
       SUP2050(NCOUNTRY,ICSPSTOR)    = SUPCSP2050
       SUP2050(NCOUNTRY,IGEOEL)      = SUPGEL2050
       SUP2050(NCOUNTRY,IHYDRO)      = SUPHYD2050
       SUP2050(NCOUNTRY,ITIDAL)      = SUPTID2050
       SUP2050(NCOUNTRY,IWAVE)       = SUPWAV2050
       SUP2050(NCOUNTRY,IGEOHT)      = SUPGHT2050
C
C WWSTOT     = TOTAL 2050 END-USE LOAD (GW) FOR EACH 1..MXCOUNTRY COUNTRY
C TLOADSEC   = 2050 END-USE LOAD (GW) FOR EACH 1..MXSECTOR SECTOR BY COUNTRY
C
       WWSTOT(  NCOUNTRY)            = TLOADTOT
       TLOADSEC(NCOUNTRY,IRESID)     = BLOADRES
       TLOADSEC(NCOUNTRY,ICOMM)      = BLOADCOM
       TLOADSEC(NCOUNTRY,IIND)       = BLOADIND
       TLOADSEC(NCOUNTRY,ITRAN)      = BLOADTRA
       TLOADSEC(NCOUNTRY,IAGFF)      = BLOADAGF
       TLOADSEC(NCOUNTRY,IOTH)       = BLOADOTH
C
C FRCH2SEC   = FRACTION OF END-USE POWER DEMAND EACH 1..MXSECTOR SECTOR
C              GOING TO H2 ELECTROLYSIS/COMPRESSION/STORAGE
C
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       FRCH2SEC(NCOUNTRY,IRESID)     = FRACREH2
       FRCH2SEC(NCOUNTRY,ICOMM)      = FRACCOH2
       FRCH2SEC(NCOUNTRY,IIND)       = FRACINH2
       FRCH2SEC(NCOUNTRY,ITRAN)      = FRACTRH2
       FRCH2SEC(NCOUNTRY,IAGFF)      = FRACAFH2
       FRCH2SEC(NCOUNTRY,IOTH)       = FRACOTH2
C
C EXISTPHSC = EXISTING PUMPED-HYDRO STORAGE (PHS) INSTALLED CAPACITY (GW)
C             IN COUNTRY
C EXISOLTHC = EXISTING SOLAR THERMAL NAMEPLATE CAPACITY (GW) IN COUNTRY
C             THIS IS USUALLY USED FOR HEATING WATER
C
       EXISTPHSC(NCOUNTRY)           = EXISTPHS
       EXISOLTHC(NCOUNTRY)           = EXISOLTHM
C
C AREALAND   = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF COUNTRY
C AREALKM2C  = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF COUNTRY
C BAULOADGW  = 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOE1   = 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALTH  = 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C              COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C              MORTALITY NUMBERS AMORT50F, AMOTCURF INCLUDE ALL AIR POL DEATHS
C BAUCLIMATE = 2050 BAU CLIMATE COST ($2013 CENTS/KWH-ALL-ENERGY)
C BAULOADC   = COUNTRY 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOEC   = COUNTRY 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALC   = COUNTRY 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C BAUCLIMC   = COUNTRY 2050 BAU CLIM COST ($2013 CENTS/KWH-ALL-ENERGY) IN
C AMORTCURF  = 2016 AIR POLLUTION MORTALITY BY COUNTRY FROM WHO READ IN
C AMORT50F   = 2050 AIR POLLUTION MORTALITY BY COUNTRY READ IN FROM FILE
C AMORTCURC  = 2016 AIR POL MORTALITY BY COUNTRY IN ARRAY
C AMORT50C   = 2050 AIR POL MORTALITY BY COUNTRY IN ARRAY
C AJOBLOSSC  = JOB LOSS IN COUNTRY, AS CALCULATED FROM SPREADSHEET
C OPJOBSC    = STATE/COUNTRY LONG-TERM, FULL-TIME OPERATIONAL JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. ADJUST HERE SO FOR NEW+EXISTING
C              AND BASED ON UPDATED NAMEPLATE CAPACITIES
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CONJOBSC   = COUNTRY LONG-TERM, FULL-TIME CONSTRUCTION JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. KEEP BASED ON NEW NAMEPLATE.
C              ADJUST HERE ONLY FOR NAMEPLATE CAPACITY.
C              THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CO2E2050C  = COUNTRY TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C
       AREALKM2C(NCOUNTRY)           = AREALAND
       BAULOADC( NCOUNTRY)           = BAULOADGW
       BAULCOEC( NCOUNTRY)           = BAULCOE1
       BAUHEALC( NCOUNTRY)           = BAUHEALTH
       BAUCLIMC( NCOUNTRY)           = BAUCLIMATE
       AMORTCURC(NCOUNTRY)           = AMORTCURF
       AMORT50C( NCOUNTRY)           = AMORT50F
C
       AJOBLOSSC(NCOUNTRY)           = AJOBLOSSI
       DO LJ = 1, MXJOBCAT
        OPJOBSC(NCOUNTRY,LJ)         = OPJOBSI(LJ)
        CONJOBC(NCOUNTRY,LJ)         = CONJOBI(LJ)
       ENDDO
C
       CO2E2050C(NCOUNTRY)           = TONNECO2E
C
C SDTRANLENC = ADDITIONAL (BEYOND BAU) AC/HVAC TRANSMISSION LINES (KM)
C              NEEDED FOR ANNUAL AVERAGE POWER IN COUNTRY (DOES NOT INCLUD
C              HVDC, WHICH IS ESTIMATED SEPARATELY). USE TO CALCULATE CAPITAL
C              COST OF NON-HVDC TRANSMISSION. ANNUAL COST AND JOBS
C              ALREADY ACCOUNTED FOR.
C
       SDTRANLENC(NCOUNTRY)          = SDTRANSMIS
C
       GOTO 113
C      CONTINUE READING countrystats.dat
```

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C
 115   CLOSE(KDAT)
C      FINISH READING countrystats.dat
C
       IF (IGRIDUSE.EQ.0) THEN
        WRITE(IOUT,*)'POWERWOLD: IFCONUS=0 BUT IGRIDUSE=0. SET GRIDUSE'
        STOP
       ENDIF
C
C ***************************************************************************
C    READ heatfrac.dat TO READ FRAC OF TOTAL HEAT+ELEC LOADS GOING TO HEAT
C ***************************************************************************
C FELECSEC = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECRICITY.
C            THE REST GOES TO HEAT.
C FHTBUILD = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C FHTIND   = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN INDUSTRIAL SECTOR THAT
C            IS USED FOR HIGH-TEMPERATURE PROCESSES
C
 211   READ(KHTE,209) DUMMY
 209   FORMAT(A14)
       IF (DUMMY.NE.'BEGIN') GOTO 211
C
       IHTREG = 0
 212   READ(KHTE,207,END=213) COUNTRY, FHTBUILD, FHTINDUS
 207   FORMAT(A14,1X,0PF5.3,12X,0PF5.3)
C
C IHTREG   = NUMBER OF COUNTRIES/REGIONS IN heatfrac.dat FOR WHICH HEAT/
C            HEAT+ELEC RATIOS PROVIDED.
C
       IHTREG           = IHTREG + 1
C
       IF (IHTREG.GT.MXCOUNTRY) THEN
        WRITE(IOUT,*)'POWERWORLD: IHTREG>MXCOUNTRY ',IHTREG,MXCOUNTRY
        STOP
       ENDIF
C
C NAMHTREG = NAME OF EACH 1..IHTREG COUNTRY OR REGION
C FELBUILD = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR ELECTRICITY USED IN BUILDINGS (REST FOR LOW-T HEAT)
C FELIND   = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN INDUSTRIAL SECTOR THAT
C            IS USED FOR ELECTRICITY (REST FOR HIGH-TEMPERATURE PROCESSES)
C CPERFORM = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C            (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C FHTBUILD = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C FISHEAT  = FRAC OF TOTAL ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C            AFTER HEAT HAS BEEN TURNED TO ELECTRICITY FOR HEAT PUMPS
C FHTHPUMP = FRAC OF TOTAL HEAT+ELEC IN RES/COM/GOV BUILDINGS THAT IS
C            FOR LOW-TEMP HEAT USED IN BUILDINGS (AIR/WATER) ASSUMING
C            THE HEAT IS OBTAINED FROM HEAT PUMPS RUNNING ON ELECTRICITY
C            (THUS THE FRACTION IS REDUCED TO FISHEAT/(FISHEAT+FNONHEAT)
C             SINCE NEED MUCH LESS ELECTRICITY TO MOVE HEAT W/HEAT PUMPT THAN
C             NEEDED IF DIRECT HEAT IS PRODUCED.
C FNONHEAT = FRAC OF TOTAL HEAT+ELEC IN BUILDINGS FOR ELECTRICITY
C
       FNONHEAT         = 1. - FHTBUILD
       FISHEAT          = FHTBUILD / CPERFORM
       FHTHPUMP         = FISHEAT / (FISHEAT + FNONHEAT)
C
       NAMHTREG(IHTREG) = COUNTRY
       FELBUILD(IHTREG) = 1. - FHTHPUMP
       FELIND(  IHTREG) = 1. - FHTINDUS
C
       GOTO 212
 213   CONTINUE
C
C ***************************************************************************
C     GO THROUGH EACH COUNTRY AND ASSIGN VALUES OF FELECSEC TO EACH SECTOR
C ***************************************************************************
C FELECSEC = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECRICITY.
C            THE REST GOES TO HEAT.
C FELBUILD = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR ELECTRICITY USED IN BUILDINGS (REST FOR LOW-T HEAT)
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C FELIND   = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN INDUSTRIAL SECTOR THAT
C            IS USED FOR ELECTRICITY (REST FOR HIGH-TEMPERATURE PROCESSES)
C IHTREG   = NUMBER OF COUNTRIES/REGIONS IN heatfrac.dat FOR WHICH HEAT/
C            HEAT+ELEC RATIOS PROVIDED.
C NAMECOUN = NAME OF EACH 1..NCOUNTRY COUNTRY
C GRIDCOUN = NAME OF EACH 1..NCOUNTRY GRID REGION THE COUNTRY LIES IN
C
       DO 215 I             = 1, NCOUNTRY
        COUNTRY             = NAMECOUN(I)
C
C ***************************************************************************
C              CHECK FOR INDIVIDUAL COUNTRIES IN heatfrac.dat
C ***************************************************************************
C
        DO J  = 1, IHTREG
         IF (NAMHTREG(J).EQ.COUNTRY) THEN
          GOTO 214
         ENDIF
        ENDDO
C
C ***************************************************************************
C                 CHECK FOR REGIONAL DATA IN heatfrac.dat
C ***************************************************************************
C IHTREG     = NUMBER OF COUNTRIES/REGIONS IN heatfrac.dat FOR WHICH HEAT/
C              HEAT+ELEC RATIOS PROVIDED.
C ASIA-OTHER = ASIA OTHER THAN CHINA AND INDIA
C LAM-OTHER  = LATIN AMERICA AND CARIBBEAN OTHER THAN BRAZIL
C MEA-OTHER  = MIDDLE EAST AND AFRICA OTHER THAN SOUTH AFRICA AND NIGERIA
C REF-OTHER  = REFORMING ECONOMIES OTHER THAN POLAND AND RUSSIA
C              REFORMING COUNTRIES: IN CENTRAL+EASTERN EUROPE+FORMER SOVIET UNION
C OECD-OTHER = OECD IN 1990 OTHER THAN AUSTRALIA,FRANCE,GERMANY,US,UK,JAPAN,ITALY
C              OECD: N.AMERICAL, WESTERN EUROPE, PACIFIC OECD
C
        GRIDNAM             = GRIDCOUN(I)
        DO J                = 1, IHTREG
         NH                 = NAMHTREG(J)
         IF (    GRIDNAM.EQ.'CENTRAL-ASIA'  .AND.NH.EQ.'ASIA-OTHER')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'SOUTHEAST-ASIA'.AND.NH.EQ.'ASIA-OTHER')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'PHILIPPINES'   .AND.NH.EQ.'ASIA-OTHER')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'TAIWAN'        .AND.NH.EQ.'ASIA-OTHER')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'SOUTH-AMERICA' .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'SOUTHAM-SE'    .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'SOUTHAM-NW'    .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'CUBA'          .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'HAITI'         .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'JAMAICA'       .AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'CENTRAL-AMERIC'.AND.NH.EQ.'LAM-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'AFRICA'        .AND.NH.EQ.'MEA-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'AFRICA-EAST'   .AND.NH.EQ.'NIGERIA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'AFRICA-NORTH'  .AND.NH.EQ.'MEA-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'AFRICA-SOUTH'.AND.NH.EQ.'SOUTH AFRICA')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'AFRICA-WEST'   .AND.NH.EQ.'NIGERIA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'MADAGASCAR'    .AND.NH.EQ.'MEA-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'MIDEAST'       .AND.NH.EQ.'MEA-OTHER') THEN
          GOTO 214
C        ELSEIF (GRIDNAM.EQ.'ISRAEL'        .AND.NH.EQ.'MEA-OTHER') THEN
         ELSEIF (GRIDNAM.EQ.'ISRAEL'        .AND.NH.EQ.'AUSTRALIA') THEN
          GOTO 214
```

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C
C BREAK UP EUROPE INTO COUNTRIES. GERMANY, ITALY, FRANCE, POLAND, UK
C ALREADY ACCOUNTED FOR
C
C         ELSEIF (GRIDNAM.EQ.'EUROPE'        .AND.NH.EQ.'OECD-OTHER')THEN
C          GOTO 214
          ELSEIF (COUNTRY.EQ.'IRELAND'   .AND.NH.EQ.'UNITED KINGDOM')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SCOTLAND'  .AND.NH.EQ.'UNITED KINGDOM')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SPAIN'         .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'GIBRALTAR'     .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'PORTUGAL'      .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'GREECE'        .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'CYPRUS'        .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'MALTA'         .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'ALBANIA'       .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'BULGARIA'      .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'MACEDONIA'     .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SERBIA AND MON'.AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'MONTENEGRO'    .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'KOSOVO'        .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'CROATIA'       .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'ROMANIA'       .AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'BOSNIA-HERZEGO'.AND.NH.EQ.'ITALY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'HUNGARY'       .AND.NH.EQ.'FRANCE')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'AUSTRIA'       .AND.NH.EQ.'FRANCE')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SWITZERLAND'   .AND.NH.EQ.'FRANCE')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SLOVENIA'      .AND.NH.EQ.'FRANCE')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'CZECH REPUBLIC'.AND.NH.EQ.'GERMANY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'LUXEMBOURG'    .AND.NH.EQ.'GERMANY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'BELGIUM'       .AND.NH.EQ.'GERMANY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'NETHERLANDS'   .AND.NH.EQ.'GERMANY')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'DENMARK'       .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'NORWAY'        .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'SWEDEN'        .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'FINLAND'       .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'LITHUANIA'     .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'LATVIA'        .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'ESTONIA'       .AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'MOLDOVA REPUBL'.AND.NH.EQ.'RUSSIA')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'BELARUS'       .AND.NH.EQ.'POLAND')THEN
           GOTO 214
          ELSEIF (COUNTRY.EQ.'UKRAINE'       .AND.NH.EQ.'POLAND')THEN
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          GOTO 214
         ELSEIF (COUNTRY.EQ.'SLOVAKIA'      .AND.NH.EQ.'POLAND')THEN
          GOTO 214
C
C        ELSEIF (GRIDNAM.EQ.'ICELAND'       .AND.NH.EQ.'OECD-OTHER')THEN
         ELSEIF (GRIDNAM.EQ.'ICELAND'       .AND.NH.EQ.'RUSSIA')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'NEW-ZEALAND'   .AND.NH.EQ.'AUSTRALIA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'RUSSIA'        .AND.NH.EQ.'RUSSIA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'CHINA'         .AND.NH.EQ.'CHINA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'JAPAN'         .AND.NH.EQ.'JAPAN') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'SOUTH-KOREA'   .AND.NH.EQ.'OECD-OTHER')THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'INDIA'         .AND.NH.EQ.'INDIA') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'MAURITIUS'     .AND.NH.EQ.'MEA-OTHER') THEN
          GOTO 214
         ELSEIF (GRIDNAM.EQ.'HICC'       .AND.NH.EQ.'GRAN-CANARIA') THEN
          GOTO 214
         ELSEIF (IFSTATES.EQ.1.AND.GRIDNAM.NE.'HICC'.
     1                                  AND.NH.EQ.'UNITED STATES') THEN
          GOTO 214
         ENDIF
        ENDDO
C
C CAN'T FIND REGION IN heatfrac.dat CORRESPONDING TO GRIDNAM
C
        WRITE(IOUT,*)'POWERWORLD1:GRIDNAM.NE.NH: ',GRIDNAM,NAMECOUN(I)
        STOP
C
C ASSIGN VALUES OF FELECSEC FROM COUNTRY OR REGIONAL DATA FROM heatfrac.dat
C
 214    FELECSEC(I,IRESID) = FELBUILD(J)
        FELECSEC(I,ICOMM)  = FELBUILD(J)
        FELECSEC(I,IIND)   = FELIND(  J)
        FELECSEC(I,ITRAN)  = 1.
        FELECSEC(I,IAGFF)  = 1.
        FELECSEC(I,IOTH)   = 1.
C
 215   CONTINUE
C      CONTINUE I = 1, NCOUNTRY
C
C ***************************************************************************
C  SUMMARIZE LOAD STATISTICS FOR GRID REGIONS AND WRITE TO FILE countrydata.out
C ***************************************************************************
C NUMGRIDS  = NUMBER OF GRID REGIONS AMONG AlL COUNTRIES
C NCOUNGRID = NUMBER OF COUNTRIES IN EACH 1..NUMGRIDS GRID REGION
C NAMECOUN  = NAME OF EACH 1..NCOUNTRY COUNTRY
C NAMCOUNGR = NAME OF EACH 1..NCOUNGRID COUNTRY IN EACH 1..NUMGRIDS REGION
C NUMCOUNGR = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C
       ICOUN          = 0
       SUMALL         = 0.
       SUMH2ALL       = 0.
       PHSALL         = 0.
       STHALL         = 0.
C
       DO J           = 1, NUMGRIDS
        WRITE(KOUT,116) NAMEGRID(J)
C
        DO I          = 1, NCOUNGRID(J)
         ICOUN        = ICOUN + 1
         IC           = NUMCOUNGR(J,I)
C
C SUMWWS    = SUM OF END-USE LOAD (GW) OVER ALL COUNTRIES IN DATASET
C EXISTPHSR = EXISTING PUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (GW)
C             IN GRID REGION J=1,NUMGRIDS
C EXISOLTHR = EXISTING SOLAR THERMAL FOR HEAT NAMEPLATE CAPACITY (GW)
C             IN GRID REGION J=1,NUMGRIDS
C
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         SUMWWS(   J) = SUMWWS(J)    + WWSTOT(   IC)
         EXISTPHSR(J) = EXISTPHSR(J) + EXISTPHSC(IC)
         EXISOLTHR(J) = EXISOLTHR(J) + EXISOLTHC(IC)
C
C AREALKM2C  = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF COUNTRY
C AREALKM2R  = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF GRID REGION
C BAULOADC   = COUNTRY 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOEC   = COUNTRY 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALC   = COUNTRY 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C BAUCLIMC   = COUNTRY 2050 BAU CLIM COST ($2013 CENTS/KWH-ALL-ENERGY) IN
C BAULOADR   = REGION 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOER   = REGION 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALR   = REGION 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C              COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C              MORTALITY NUMBERS AMORT50F, AMOTCURF INCLUDE ALL AIR POL DEATHS
C BAUCLIMR   = REGION 2050 BAU CLIM COST ($2013 CENTS/KWH-ALL-ENERGY) IN
C              CALCULATE A WEIGHTED AVERAGE LCOE, HEALTH, AND CLIMATE
C              COST (CENTS/KWH), WEIGHTING WITH END USE LOAD OF COUNTRY.
C AMORTCURC  = 2016 AIR POL MORTALITY BY COUNTRY IN ARRAY
C AMORT50C   = 2050 AIR POL MORTALITY BY COUNTRY IN ARRAY
C AMORTCURR  = 2016 AIR POL MORTALITY BY REGION IN ARRAY
C AMORT50R   = 2050 AIR POL MORTALITY BY REGION IN ARRAY
C AJOBLOSSR  = JOB LOSS IN REGION, AS CALCULATED FROM SPREADSHEET
C OPJOBSR    = REGION LONG-TERM, FULL-TIME OPERATIONAL JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. ADJUST HERE SO FOR NEW+EXISTING
C              AND BASED ON UPDATED NAMEPLATE CAPACITIES
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CONJOBR    = REGION LONG-TERM, FULL-TIME CONSTRUCTION JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. KEEP BASED ON NEW NAMEPLATE.
C              ADJUST HERE ONLY FOR NAMEPLATE CAPACITY.
C              THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CO2E2050R  = REGION TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C
         AREALKM2R(J) = AREALKM2R(J) + AREALKM2C(IC)
         BAULOADR( J) = BAULOADR( J) + BAULOADC( IC)
         BAULCOER( J) = BAULCOER( J) + BAULCOEC( IC) * BAULOADC(IC)
         BAUHEALR( J) = BAUHEALR( J) + BAUHEALC( IC) * BAULOADC(IC)
         BAUCLIMR( J) = BAUCLIMR( J) + BAUCLIMC( IC) * BAULOADC(IC)
         AMORTCURR(J) = AMORTCURR(J) + AMORTCURC(IC)
         AMORT50R( J) = AMORT50R( J) + AMORT50C( IC)
C
         AJOBLOSSR(J) = AJOBLOSSR(J) + AJOBLOSSC(IC)
C
         DO LJ = 1, MXJOBCAT
          OPJOBSR(J,LJ) = OPJOBSR(J,LJ) + OPJOBSC(IC,LJ)
          CONJOBR(J,LJ) = CONJOBR(J,LJ) + CONJOBC(IC,LJ)
         ENDDO
C
         CO2E2050R(J) = CO2E2050R(J) + CO2E2050C(IC)
C
C SDTRANLENR = ADDITIONAL (BEYOND BAU) AC/HVAC TRANSMISSION LINES (KM)
C              NEEDED FOR ANNUAL AVERAGE POWER IN REGION (DOES NOT INCLUD
C              HVDC, WHICH IS ESTIMATED SEPARATELY). USE TO CALCULATE CAPITAL
C              COST OF NON-HVDC TRANSMISSION. ANNUAL COST AND JOBS
C              ALREADY ACCOUNTED FOR.
C
        SDTRANLENR(J) = SDTRANLENR(J) + SDTRANLENC(IC)
C
C TLOADSUM  = SUM OF TLOADSEC (GW) AMONG COUNTRIES IN EACH J=1..NUMGRIDS REGION
C TSECALL   = SUM OF TLOADSEC (GW) AMONG ALL COUNTRIES OVER ALL GRID REGIONS
C TLOADSEC  = 2050 END-USE LOAD (GW) FOR EACH 1..MXSECTOR SECTOR BY COUNTRY
C H2COUN    = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C             OVER ALL SECTORS K=1,MXSECTOR IN COUNTRY IC
C H2LOADSEC = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE IN
C             COUNTRY IC AND SECTOR K
C H2SECGRID = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C             OVER ALL COUNTRIES IN GRID REGION J FOR SECTOR K
C H2SECALL  = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
```

```
C             OVER ALL COUNTRIES IN SECTOR K
C SUMH2REG  = GW-ELEC USED FOR H2 ELECTROLYSIS/COMPRESSION/STORAGE SUMMED
C             OVER ALL COUNTRIES AND SECTORS IN GRID REGION J
C FELECSEC  = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECRICITY.
C             THE REST GOES TO HEAT.
C ELLOADSEC = TOTAL GW USED IN SECTOR IN COUNTRY FOR ELECTRIC POWER APPLICATIONS
C             REST IS USED FOR HEAT APPLICATIONS
C EXISTPHSC = EXISTING PUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (GW)
C             IN COUNTRY
C EXISOLTHC = EXISTING SOLAR THERMAL FOR HEAT NAMEPLATE CAPACITY (GW) IN COUNTRY
C
         H2COUN          = 0.
         DO K            = 1, MXSECTOR
          TLOADSUM(J,K)  = TLOADSUM(J,K) + TLOADSEC(IC,K)
          TSECALL(   K)  = TSECALL(   K) + TLOADSEC(IC,K)
C
          H2LOADSEC      = FRCH2SEC(IC,K) * TLOADSEC(IC,K)
          H2COUN         = H2COUN         + H2LOADSEC
          H2SECGRID(J,K) = H2SECGRID(J,K) + H2LOADSEC
          H2SECALL(   K) = H2SECALL(   K) + H2LOADSEC
          SUMH2REG( J)   = SUMH2REG(J)    + H2LOADSEC
C
          ELLOADSEC(J,K) = ELLOADSEC(J,K)+FELECSEC(IC,K)*TLOADSEC(IC,K)
         ENDDO
C
         WRITE(KOUT,117) I, NAMCOUNGR(J,I), ICOUN, WWSTOT(IC),
     1                   (TLOADSEC(IC,K),K=1,MXSECTOR),
     1                    PCT*H2COUN/WWSTOT(IC),
     1                   (PCT*FRCH2SEC(IC,K),K=1,MXSECTOR),
     1                    EXISTPHSC(IC),EXISOLTHC(IC),
     1                   (PCT*FELECSEC(IC,K),K=1,MXSECTOR)
        ENDDO
C       ENDDO I = 1, NCOUNGRID
C
C DIVIDE BY REGIONAL LOAD TO OBTAIN AVERAGE REGIONAL VALUES OF BAU LCOE
C HEALTH, AND CLIMATE COSTS PER KWH
C
        BAULCOER( J) = BAULCOER( J) / BAULOADR(J)
        BAUHEALR( J) = BAUHEALR( J) / BAULOADR(J)
        BAUCLIMR( J) = BAUCLIMR( J) / BAULOADR(J)
C
C FRCH2REG  = FRACTION OF END-USE POWER DEMAND EACH 1..MXSECTOR SECTOR
C             IN EACH 1..NUMGRIDS GRID GOING TO H2 ELECTROL/COMPRESSION/STORAGE
C FELECREG  = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C             IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C TLOADSUM  = SUM OF TLOADSEC (GW) AMONG COUNTRIES IN EACH J=1..NUMGRIDS REGION
C TLOADSEC  = 2050 END-USE LOAD (GW) FOR EACH 1..MXSECTOR SECTOR BY COUNTRY
C ELLOADSEC = TOTAL GW USED IN SECTOR IN COUNTRY FOR ELECTRIC POWER APPLICATIONS
C             REST IS USED FOR HEAT APPLICATIONS
C
        DO K           = 1, MXSECTOR
         FRCH2REG(J,K) = H2SECGRID(J,K) / TLOADSUM(J,K)
         FELECREG(J,K) = ELLOADSEC(J,K) / TLOADSUM(J,K)
        ENDDO
C
C SUMALL = SUM OF END USE LOADS (GW) OVER ALL GRID REGIONS
C PHSALL = SUM OF EXISTING PHS NAMEPLATE CAPACITY OVER ALL GRID REGIONS
C STHALL = SUM OF EXISTING SOL THERMAL FOR HEAT  NAMEPLATE CAPAC OVER ALL GRID REGIONS
C
        SUMALL         = SUMALL     + SUMWWS(   J)
        SUMH2ALL       = SUMH2ALL   + SUMH2REG( J)
        PHSALL         = PHSALL     + EXISTPHSR(J)
        STHALL         = STHALL     + EXISOLTHR(J)
C
        IF (NCOUNGRID(J).GT.1) THEN
         WRITE(KOUT,118) SUMWWS(J), (TLOADSUM(J,K),K=1,MXSECTOR),
     1                   PCT*SUMH2REG(J)/SUMWWS(J),
     1                  (PCT*FRCH2REG(J,K),K=1,MXSECTOR),
     1                   EXISTPHSR(J),EXISOLTHR(J)
        ELSE
         WRITE(KOUT,*)
        ENDIF
       ENDDO
C      ENDDO J = 1, NUMGRIDS
C
```

```
      WRITE(KOUT,119) SUMALL, (TSECALL(K),K=1,MXSECTOR),
     1         PCT*SUMH2ALL/SUMALL,
     1         (PCT*H2SECALL(K)/TSECALL(K),K=1,MXSECTOR),
     1         PHSALL,STHALL
C
 116   FORMAT('GRID REGION ',A14,'        2050 GW-TOTLOAD ',
     1      'GW-RES   GW-COM   GW-IND   GW-TRA   GW-AGF   GW-OTH',/,
     1       40X,'%H2-TOT  %H2-RES  %H2-COM  %H2-IND  %H2-TRA  ',
     1      '%H2-AGF  %H2-OTH',/,40X,'PHSEXISTGW SOLTHEXISGW %ELECRES ',
     1      '%ELECCOM %ELECIND %ELECTRA %ELECAGF %ELECOTH')
C
 117   FORMAT('   COUNTRY      ',I3,1X,A14,1X,I3,7(1X,0PF8.2),/,
     1                                    38X,7(1X,0PF8.2),/,
     1                                    38X,8(1X,0PF8.2))
 118   FORMAT('      REGIONAL SUM ',19X,7(1X,0PF8.2),/,
     1                             38X,7(1X,0PF8.2),/,
     1                             38X,2(1X,0PF8.2))
 119   FORMAT('      ALL-COUNTRIES',19X,7(1X,0PF8.2),/,
     1                             38X,7(1X,0PF8.2),/,
     1                             38X,2(1X,0PF8.2))
C
C ***************************************************************************
C  SUMMARIZE SUPPLY STATISTICS FOR GRID REGIONS AND WRITE TO FILE countrydata.out
C ***************************************************************************
C NUMGRIDS  = NUMBER OF GRID REGIONS AMONG AlL COUNTRIES
C NAMECOUN  = NAME OF EACH 1..NCOUNTRY COUNTRY
C NAMCOUNGR = NAME OF EACH 1..NCOUNGRID COUNTRY IN EACH 1..NUMGRIDS REGION
C NUMCOUNGR = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C
       ICOUN          = 0
       TGWALLGLB      = 0.
       EGWALLGLB      = 0.
       SUPALLGLB      = 0.
       TGWGATGLB      = 0.
C
       DO J           = 1, NUMGRIDS
        WRITE(KOUT,121) NAMEGRID(J)
C
        DO I          = 1, NCOUNGRID(J)
         ICOUN        = ICOUN + 1
         IC           = NUMCOUNGR(J,I)
C
C TGWINSTREG = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC FOR DEVICE K
C EGWINSTREG = GW-SUM OVER REG J, EXISTING NAMEPL CAPAC FOR DEVICE K
C TGWGATREG  = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC DEVICE K GATOR SIMS
C SUPGWREG   = GW-SUM OVER REG J, 2050 END-USE POWER SUPPLIED BY DEVICE K
C TGWINSTALL = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY IN 2050
C TGWINSTGAT = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY GATOR-GCMOM SIMS
C EGWINSTALL = EXISTING INSTALLED GW OF EACH 1..MXCAP DEVICE
C SUP2050    = 2050 ELECTRIC POWER (NOT HEAT) SUPPLY (GW) BY 1..MXCAP DEVICE
C TGWINSTGLB = GW-SUM ALL COUNTRIES, 2050 NEW+EXIST NAMEPL CAPAC DEVICE K
C EGWINSTGLB = GW-SUM ALL COUNTRIES, 2014 EXIST NAMEPLATE CAPAC DEVICE K
C SUPGLOB    = GW-SUM ALL COUNTRIES, 2050 END-USE POWER SUPPLIED DEVICE K
C GATGLOB    = GW-SUM ALL COUNTRIES, 2050 NEW+EXIST NP CAPAC DEVICE K GATOR SIMS
C
         EGWALLCOUN      = 0.
         SUPALLCOUN      = 0.
         TGWGATCOUN      = 0.
C
         DO K            = 1, MXCAP
          TGWINSTREG(J,K) = TGWINSTREG(J,K) + TGWINSTALL(IC,K)
          EGWINSTREG(J,K) = EGWINSTREG(J,K) + EGWINSTALL(IC,K)
          SUPGWREG(  J,K) = SUPGWREG(  J,K) + SUP2050(   IC,K)
          TGWGATREG( J,K) = TGWGATREG( J,K) + TGWINSTGAT(IC,K)
          TGWALLCOUN(IC)  = TGWALLCOUN(IC)  + TGWINSTALL(IC,K)
          EGWALLCOUN      = EGWALLCOUN      + EGWINSTALL(IC,K)
          SUPALLCOUN      = SUPALLCOUN      + SUP2050(   IC,K)
          TGWGATCOUN      = TGWGATCOUN      + TGWINSTGAT(IC,K)
          TGWINSTGLB(  K) = TGWINSTGLB(K)   + TGWINSTALL(IC,K)
          EGWINSTGLB(  K) = EGWINSTGLB(K)   + EGWINSTALL(IC,K)
          SUPGLOB(     K) = SUPGLOB(   K)   + SUP2050(   IC,K)
          GATGLOB(     K) = GATGLOB(   K)   + TGWINSTGAT(IC,K)
         ENDDO
C
```

```
C TGWALLREG  = GW-SUM REGION J, 2050 NEW+EXIST NAMEPL CAPAC ALL DEVICES
C EGWALLREG  = GW-SUM REGION J, 2014 EXIST NAMEPLATE CAPAC ALL DEVICES
C SUPALLREG  = GW-SUM REGION J, 2050 END-USE POWER SUPPLIED ALL SOURCES
C TGWALLREG  = GW-SUM REGION J, 2050 NEW+EXIST NP CAPAC ALL DEVICE GATOR SIMS
C TGWALLCOUN = GW-SUM COUNTRY IC, 2050 NEW+EXIST NAMEPL CAPAC ALL DEVICES
C EGWALLCOUN = GW-SUM COUNTRY IC, 2014 EXIST NAMEPLATE CAPAC ALL DEVICES
C SUPALLCOUN = GW-SUM COUNTRY IC, 2050 END-USE POWER SUPPLIED ALL SOURCES
C              DIFFERS FROM SUPALL, WHICH IS FOR ELECTRIC POWER SOURCES ONLY
C SUPALL     = 2050 TOTAL POWER SUPPLY (GW) ALL ELEC POW SOURCES (NOT SUPGHT2050)
C TGWGATCOUN = GW-SUM COUNTRY IC, 2050 NEW+EXIST NP CAPAC ALL DEVICE GATOR SIMS
C TGWADCSPR  = ADDED CSP TURBINES (GW) IN REGION FROM SPREADSHEET TO
C              MEET CONTINUOUS LOAD. USED ONLY TO CALCULATE JOB NUMBERS
C              NEW SPREADSHEETS SHOULD HAVE 0 VALUES
C              OLD SPREADSHEET VALUES WERE TWMCSPORIG*0.6
C
         TGWALLREG(J)    = TGWALLREG(J) + TGWALLCOUN(IC)
         EGWALLREG(J)    = EGWALLREG(J) + EGWALLCOUN
         SUPALLREG(J)    = SUPALLREG(J) + SUPALLCOUN
         GATALLREG(J)    = GATALLREG(J) + TGWGATCOUN
         TGWADCSPR(J)    = TGWADCSPR(J) + TGWADCSPC( IC)
C
C FLOADREG  = FRAC 2050 END USE ELEC POWER FROM EACH 1..MXCAP DEVICE IN REGION
C
         DO K            = 1, MXCAP
          FLOADREG(J,K)  = SUPGWREG(J,K) / SUPALLREG(J)
         ENDDO
C
         WRITE(KOUT,122) I, NAMCOUNGR(J,I), ICOUN,
     1                     (TGWINSTALL(IC,K),K=1,MXCAP), TGWALLCOUN(IC),
     1                     (EGWINSTALL(IC,K),K=1,MXCAP), EGWALLCOUN,
     1                     (SUP2050(   IC,K),K=1,MXCAP), SUPALLCOUN,
     1                     (TGWINSTGAT(IC,K),K=1,MXCAP), TGWGATCOUN
        ENDDO
C       ENDDO I = 1, NCOUNGRID
C
C TGWINSTREG = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC FOR DEVICE K
C EGWINSTREG = GW-SUM OVER REG J, 2014 EXIST NAMEPL CAPAC FOR DEVICE K
C TGWGATREG  = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC DEVICE K GATOR SIMS
C TGWALLGLB  = GW-SUM ALL COUNTRIES, 2050 NEW+EXIST NAMEPL CAPAC ALL DEVICES
C EGWALLGLB  = GW-SUM ALL COUNTRIES, 2014 EXIST NAMEPLATE CAPAC ALL DEVICES
C SUPALLGLB  = GW-SUM ALL COUNTRIES, 2050 END-USE POWER SUPPLIED ALL SOURCES
C TGWGATGLB  = GW-SUM ALL COUNTRIES, 2050 NEW+EXIST NP CAPAC ALL DEVICE GATOR SIMS
C
        TGWALLGLB      = TGWALLGLB  + TGWALLREG(J)
        EGWALLGLB      = EGWALLGLB  + EGWALLREG(J)
        SUPALLGLB      = SUPALLGLB  + SUPALLREG(J)
        TGWGATGLB      = TGWGATGLB  + GATALLREG(J)
C
        IF (NCOUNGRID(J).GT.1) THEN
         WRITE(KOUT,123) (TGWINSTREG(J,K),K=1,MXCAP), TGWALLREG(J),
     1                   (EGWINSTREG(J,K),K=1,MXCAP), EGWALLREG(J),
     1                   (SUPGWREG(  J,K),K=1,MXCAP), SUPALLREG(J),
     1                   (TGWGATREG( J,K),K=1,MXCAP), GATALLREG(J)
        ELSE
         WRITE(KOUT,*)
        ENDIF
       ENDDO
C      ENDDO J = 1, NUMGRIDS
C
       WRITE(KOUT,124) (TGWINSTGLB(K),K=1,MXCAP), TGWALLGLB,
     1                 (EGWINSTGLB(K),K=1,MXCAP), EGWALLGLB,
     1                 (SUPGLOB(   K),K=1,MXCAP), SUPALLGLB,
     1                 (GATGLOB(   K),K=1,MXCAP), TGWGATGLB
C
 121   FORMAT(/'GRID REGION ',A14,' 2050   NEW+EX-GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
     1  'GW-SOLTH    GW-GEOHT    GW-TOT',/
     1        28X,'2014   EXIST GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
     1  'GW-SOLTH    GW-GEOHT    GW-TOT',/
     1        27X,'2050   SUPPLY GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
```

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     1  'GW-SOLTH    GW-GEOHT    GW-TOT',/
     1        21X,'2050   NEW+EXIS GAT GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
     1  'GW-SOLTH    GW-GEOHT    GW-TOT')
C
 122   FORMAT('   SUB-REGION   ',I3,1X,A14,1X,I3,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5))
C
 123   FORMAT('      REGIONAL SUM ',         19X,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5),/,
     1                                    38X,14(1X,0PF11.5),/)
C
 124   FORMAT('      ALL-REGIONS',           19X,14(1X,0PF11.4),/,
     1                                    38X,14(1X,0PF11.4),/,
     1                                    38X,14(1X,0PF11.4),/,
     1                                    38X,14(1X,0PF11.4))
C
C ***************************************************************************
C                  READ HEATING/COOLING DEGREE DAYS BY COUNTRY
C DATA IN FILE FROM 2013 AND 2014, WHICH ARE NON-LEAP YEARS (365 DAYS PER YEAR)
C                     DATA FROM http://www.degreedays.net
C ***************************************************************************
C MXCOUNHDD = MAX NUMBER OF COUNTRIES READ IN heatcooldd.dat
C NAMEREAD  = NAME OF COUNTRIES READ IN FROM FILE KHDD. SHOULD BE SAME COUNTRIES
C             AS NAMECOUN.
C
       READ(KHDD,*) DUMMY,  (NAMEREAD(I), DUMMY, I = 1, MXCOUNHDD)
       READ(KHDD,*)
C
       DO I           = 1, MXCOUNHDD
        COUNTRY       = NAMEREAD(I)
        IF (COUNTRY.EQ.'BRUNEI-DARUSSA') COUNTRY = 'BRUNEI DARUSSA'
        IF (COUNTRY.EQ.'CONGO-DEMOCRAT') COUNTRY = 'CONGO, DEMOCRA'
        IF (COUNTRY.EQ.'COSTA-RICA')     COUNTRY = 'COSTA RICA    '
        IF (COUNTRY.EQ.'IVORY-COAST')    COUNTRY = 'IVORY COAST   '
        IF (COUNTRY.EQ.'CZECH-REPUBLIC') COUNTRY = 'CZECH REPUBLIC'
        IF (COUNTRY.EQ.'DOMINICAN-REPU') COUNTRY = 'DOMINICAN REPU'
        IF (COUNTRY.EQ.'EL-SALVADOR')    COUNTRY = 'EL SALVADOR   '
        IF (COUNTRY.EQ.'EQUATORIAL-GUI') COUNTRY = 'EQUATORIAL GUI'
        IF (COUNTRY.EQ.'HONG-KONG')      COUNTRY = 'HONG KONG     '
        IF (COUNTRY.EQ.'KOREA-DEM.-PEO') COUNTRY = 'KOREA, DEM. PE'
        IF (COUNTRY.EQ.'KYRGYZ-REPUBLI') COUNTRY = 'KYRGYZ REPUBLI'
        IF (COUNTRY.EQ.'LAO-PDR')        COUNTRY = 'LAOS PDR      '
        IF (COUNTRY.EQ.'LIBYAN-ARAB-JA') COUNTRY = 'LIBYAN ARAB JA'
        IF (COUNTRY.EQ.'MOLDOVA-REPUBL') COUNTRY = 'MOLDOVA REPUBL'
        IF (COUNTRY.EQ.'MACEDONIA-FORM') COUNTRY = 'MACEDONIA     '
        IF (COUNTRY.EQ.'MOROCCO-(INC-W') COUNTRY = 'MOROCCO (INC W'
        IF (COUNTRY.EQ.'CURACAO')        COUNTRY = 'DUTCH ANTILLES'
        IF (COUNTRY.EQ.'ESWATINI-KINGD') COUNTRY = 'SWAZILAND     '
        IF (COUNTRY.EQ.'NEW-ZEALAND')    COUNTRY = 'NEW ZEALAND   '
        IF (COUNTRY.EQ.'SAUDI-ARABIA')   COUNTRY = 'SAUDI ARABIA  '
        IF (COUNTRY.EQ.'SERBIA')         COUNTRY = 'SERBIA AND MON'
        IF (COUNTRY.EQ.'SOUTH-AFRICA')   COUNTRY = 'SOUTH AFRICA  '
        IF (COUNTRY.EQ.'SRI-LANKA')      COUNTRY = 'SRI LANKA     '
        IF (COUNTRY.EQ.'SYRIAN-ARAB-RE') COUNTRY = 'SYRIAN ARAB RE'
        IF (COUNTRY.EQ.'TRINIDAD-AND-T') COUNTRY = 'TRINIDAD AND T'
        IF (COUNTRY.EQ.'UNITED-ARAB-EM') COUNTRY = 'UNITED ARAB EM'
        IF (COUNTRY.EQ.'UNITED-KINGDOM') COUNTRY = 'UNITED KINGDOM'
        IF (COUNTRY.EQ.'UNITED-STATES-') COUNTRY = 'UNITED STATES '
       NAMEREAD(I) = COUNTRY
       ENDDO
C
C NAMECOUN = NAME OF EACH 1..NCOUNTRY COUNTRY
C MAPCOUN  = GIVES I=1,MXCOUNTRY VALUE FOR EACH J=1, NCOUNTRY COUNTRY
C ISERBMON = IDENTIFIES 1..NCOUNTRY COUNTRY 'SERBIA AND MON'
C IMONT    = IDENTIFIES 1..NCOUNTRY COUNTRY 'MONTENEGRO    '
C IFSTATES = 1: DON'T NEED HEATING/COOLING DEGREE DATA SINCE OBTAINING
C            FROM GATOR-GCMOM
C
       ISERBMON       = 0
       IMONT          = 0
```

```
       DO 158 J       = 1, NCOUNTRY
        IF (NAMECOUN(J).EQ.'SERBIA AND MON') ISERBMON = J
        IF (NAMECOUN(J).EQ.'MONTENEGRO    ') IMONT    = J
C
        DO I          = 1, MXCOUNHDD
         IF (NAMEREAD(I).EQ.NAMECOUN(J).OR.
     1      (NAMEREAD(I).EQ.'UNITED STATES'.AND.IFSTATES.EQ.1)) THEN
          MAPCOUN(J)  = I
          GOTO 158
         ENDIF
        ENDDO
C
        WRITE(IOUT,*) 'POWERWORLD: COUNTRY MISSING KHDD ',NAMECOUN(J),J
        STOP
 158   CONTINUE
C      CONTINUE J = 1, NCOUNTRY

C HDDNAT   = HEATING DEGREE DAYS PER DAY (F) OF YEAR
C CDDNAT   = COOLING DEGREE DAYS PER DAY (F) OF YEAR
C HDDDAY   = HEATING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C          = DEVIATIONS BELOW MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C CDDDAY   = COOLING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C          = DEVIATIONS ABOVE MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C NDAYDATA = NUMBER OF DAYS OF COOLING/HEATING DEGREE DAY DATA FROM KHDD FILE.
C            DATA START JAN 1, 2013 TO DEC 31, 2014 (NON-LEAP YEARS)
C ID       = DAY NUMBER (1..730) OF DATA STARTING JAN 1, 2013 TO DEC 31, 2014
C
       KOUNTDAY = 0
 159   READ(KHDD,*) ID, (HDDNAT(I), CDDNAT(I), I=1,MXCOUNHDD)
C
C ID=-1 CORRESPONDS TO 2-YEAR TOTAL DATA
C
       IF (ID.EQ.-1) GOTO 161
C
       KOUNTDAY = KOUNTDAY + 1
C
       IF (ID.NE.KOUNTDAY) THEN
        WRITE(IOUT,*)'POWERWORLD: ID.NE.KOUNTDAY IN KHDD ',ID,KOUNTDAY
        STOP
       ENDIF
C
       IF (KOUNTDAY.GT.NDAYDATA) GOTO 161
C
       DO J                = 1, NCOUNTRY
        I                  = MAPCOUN(J)
        HDDDAY(J,KOUNTDAY) = HDDNAT(I)
        CDDDAY(J,KOUNTDAY) = CDDNAT(I)
       ENDDO

       GOTO 159

  161  CLOSE(KHDD)
C
       IF (KOUNTDAY.NE.NDAYDATA) THEN
        WRITE(IOUT,*)'POWERWORLD: KOUNTDAY.NE.NDAYDATA ',
     1              'IN KHDD ', KOUNTDAY,NDAYDATA
        STOP
       ENDIF
C
C ***************************************************************************
C      FOR. U.S., WEIGH DAILY VALUES FOR TWO YEARS AND LIMITED
C NUMBER OF STATIONS BY RATIO OF MONTHLY AVERAGE VALUE FROM 1949-2011 AVG TO
C MONTHLY VALUES FROM THE TWO YEARS
C ***************************************************************************
C NDAYDATA = NUMBER OF DAYS OF COOLING/HEATING DEGREE DAY DATA FROM KHDD FILE.
C            DATA START JAN 1, 2013 TO DEC 31, 2014 (NON-LEAP YEARS)
C HDDMON   = HEATING DEGREE DAYS PER MONTH (F) CONUS AVERAGE 1949-2011
C CDDMON   = COOLING DEGREE DAYS PER MONTH (F) CONUS AVERAGE 1949-2011
C ICUSA    = 1..NCOUNTRY INDEX CORRESPONDING TO U.S.A.
C HDDDAY   = HEATING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C CDDDAY   = COOLING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C
       IF (ICUSA.GT.0) THEN
        HDDUSMON = 0.
        CDDUSMON = 0.
```

```
        KDAY     = 0
        KMON     = 1
        KYEAR    = 1
        MONCUM   = LDMONTH(KYEAR,1)
C
C ADD ONE MORE DAY TO LOOP TO ENSURE LAST MONTH (DEC) INFO IS SUMMED
C
        DO I     = 1, NDAYDATA + 1
         KDAY    = KDAY + 1
         IF (I.GT.MONCUM) THEN
C
C SCALE PREVIOUS MONTH'S DAILY HDD AND CDD VALUES BY MONTHLY AVG RATIO
C THIS WILL RESULT IN US ANN AVG HDD, CDD FROM DAILY DATA EQUALLING
C THAT FROM MONTHLY DATA
C
          RATHDD           = HDDMON(KMON) / HDDUSMON
          RATCDD           = CDDMON(KMON) / CDDUSMON
          DO J             = I-LDMONTH(KYEAR,KMON), I-1
           HDDDAY(ICUSA,J) = HDDDAY(ICUSA,J) * RATHDD
           CDDDAY(ICUSA,J) = CDDDAY(ICUSA,J) * RATCDD
          ENDDO
C
C ADVANCE TO NEXT MONTH
C
          IF (I.LE.NDAYDATA) THEN
           KMON     = KMON + 1
           HDDUSMON = 0.
           CDDUSMON = 0.
           IF (KMON.EQ.13) THEN
            KDAY    = 1
            KMON    = 1
            KYEAR   = KYEAR + 1
           ENDIF
           MONCUM   = MONCUM + LDMONTH(KYEAR,KMON)
          ENDIF
C         ENDIF I.LE.NDAYDATA
C
         ENDIF
C        ENDIF I>MONTHCUM
C
         IF (I.LE.NDAYDATA) THEN
          HDDUSMON = HDDUSMON + HDDDAY(ICUSA,I)
          CDDUSMON = CDDUSMON + CDDDAY(ICUSA,I)
         ENDIF
C
        ENDDO
C       ENDDO I = 1, NDAYDATA + 1
       ENDIF
C      ENDIF ICUSA>0
C
C ***************************************************************************
C   WEIGHT COUNTRY HDDDAY, CDDDAY BY LOAD TO ESTIMATE VALUES IN GRID REGION
C ***************************************************************************
C WWSTOT    = TOTAL 2050 END-USE LOAD (GW) FOR EACH 1..MXCOUNTRY COUNTRY
C SUMWWS    = SUM OF END-USE LOAD (GW) OVER ALL COUNTRIES IN DATASET
C HDDDAY    = HEATING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C CDDDAY    = COOLING DEGREE DAYS PER DAY (F) FOR COUNTRY I=1,NCOUNTRY
C HDDREG    = HEATING DEGREE DAYS PER DAY (F) FOR REGION J = 1, NUMGRIDS
C CDDREG    = COOLING DEGREE DAYS PER DAY (F) FOR REGION J = 1, NUMGRIDS
C COUNRATIO = RATIO OF POWER LOAD IN COUNTRY TO THAT OF REG THAT COUNTRY IS IN
C NDAYDATA  = NUMBER OF DAYS OF COOLING/HEATING DEGREE DAY DATA FROM FILE.
C             DATA START JAN 1, 2013 TO DEC 31, 2014 (NON-LEAP YEARS)
C NDAYYR    = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C`
       DO J         = 1, NUMGRIDS
C
        DO I        = 1, NCOUNGRID(J)
         IC         = NUMCOUNGR(J,I)
         COUNRATIO  = WWSTOT(IC) / SUMWWS(J)
C
         L           = 0
         DO N        = 1, NYEARS
          DO K       = 1, NDAYYR(N)
C
C FOR LEAP YEARS, REPEAT 365TH DATA VALUE ON 366TH DAY OF YEAR
```

```
C WHEN RUN OUT OF NDAYDATA DATA VALUES, REPEAT DATA VALUES FOR SUBSEQ YEARS
C
           IF (K.EQ.366) THEN
            HDDREG(J,N,K) = HDDREG(J,N,K) + HDDDAY(IC,L) * COUNRATIO
            CDDREG(J,N,K) = CDDREG(J,N,K) + CDDDAY(IC,L) * COUNRATIO
           ELSE
            L         = L + 1
            IF (L.GT.NDAYDATA) L = 1
            HDDREG(J,N,K) = HDDREG(J,N,K) + HDDDAY(IC,L) * COUNRATIO
            CDDREG(J,N,K) = CDDREG(J,N,K) + CDDDAY(IC,L) * COUNRATIO
           ENDIF
C
          ENDDO
         ENDDO
C
        ENDDO
C       EDDO I = 1, NCOUNGRID
C
C DEGDAYMIN = MIN NUMBER OF HEATING OR COOLING DEGREE DAYS ON ANY DAY OF YEAR
C             USE HCDDADD NOW TO ENSURE WARMING/COOLING EACH DAY
C
        DEGDAYMIN       = 1.0E-10
C
        DO N            = 1, NYEARS
         DO K           = 1, NDAYYR(N)
          HDDREG(J,N,K) = MAX(HDDREG(J,N,K),DEGDAYMIN)
          CDDREG(J,N,K) = MAX(CDDREG(J,N,K),DEGDAYMIN)
         ENDDO
        ENDDO
C
C AVGHDD  = ANNUAL-AVERAGE HEATING DEGREE DAYS PER YEAR (F) IN GRID J=1,NUMGRIDS
C AVGCDD  = ANNUAL-AVERAGE COOLING DEGREE DAYS PER YEAR (F) IN GRID J=1,NUMGRIDS
C
        WRITE(KOUT,162) NAMEGRID(J)
        L          = 0
        DO N       = 1, NYEARS
         SUMCDD    = 0.
         SUMHDD    = 0.
         DO K      = 1, NDAYYR(N)
          L        = L + 1
          WRITE(KOUT,163) N, K, L, HDDREG(J,N,K), CDDREG(J,N,K)
          SUMCDD   = SUMCDD + CDDREG(J,N,K)
          SUMHDD   = SUMHDD + HDDREG(J,N,K)
         ENDDO
         AVGCDD(J) = AVGCDD(J) + SUMCDD
         AVGHDD(J) = AVGHDD(J) + SUMHDD
         WRITE(KOUT,165) SUMHDD, SUMCDD
        ENDDO
        AVGCDD(J) = AVGCDD(J) / NYEARS
        AVGHDD(J) = AVGHDD(J) / NYEARS
        WRITE(KOUT,203) AVGHDD(J), AVGCDD(J)
C
       ENDDO
C      ENDDO J = 1, NUMGRIDS
C
 162   FORMAT(/'YEAR DAYOY DAYOSIM     #HEATDD    #COOLDD PER DAY ',
     1         '65F GRID REGION ',A14)
 163   FORMAT(2(I3,2X),I5,4X,2(1X,0PF10.2))
 165   FORMAT('SUM OVER YEAR ',5X,2(1X,0PF10.2))
 203   FORMAT('ANNUAL AVG    ',5X,2(1X,0PF10.2)/)
C
      ENDIF
C     ENDIF IFCONUS=0
C
C ***************************************************************************
C       LIFECYCLE COST ($/KWH) AND ROUNDTRIP EFFICIENCY OF STORAGE DEVICES
C ***************************************************************************
C TES   = THERMAL EN STOR (SENSIBLE HEAT: HOT WATER TANKS; UNDERGROUND: SOIL)
C         LOW COST BUT LOW ENERGY DENSITY AND VARIABLE DISCHARGE TEMPERATURES
C         ONLY NEED TANK AND EQUIPMENT TO CHARGE/DISCHARGE
C         STORAGE MEDIA: WATER, SOIL, CONCRETE, MOLTEN SALTS INEXPENSIVE
C         DENSITY: 25 KWH/M3 FOR HEATING WATER
C         0.1-10 EURO/KWH; 50-90% EFFIC; 10-50 KWH/t; 0.001-10 MW THERMAL POWER
C         LIFETIMES: 10-30 YEARS
C PCM   = PHASE-CHANGE MATERIALS (SOLID:LIQUID OR SOLID:SOLID)
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C         ICE; NA-ACETATE TRIHYDRATE; PARAFFIN; ERITRYOL
C         PARAFFIN WAX IN WALLS MELT DURING DAY-->COOL; FREEZE AT NIGHT-->WARM
C         HIGHER COST BUT HIGHER ENERGY DENSITY AND TARGETED DISCHARGE TEMPS
C         FOR DAILY AND SEASONAL STORAGE.
C         DENSITY: 100 KWH/M3 FOR ICE
C         10-50 EUROS/KWH 75-90% EFFIC; 50-150 KWH/t; 0.001-1 MW THERMAL POWER
C         LIFETIMES: 10-30 YEARS
C TCS   = THERMAL-CHEMICAL STORAGE
C         (BINDLESS ZEOLITE; ALUMINO-PHOSPHATE; MGSO4*6H2O)
C         8-100 EUROS/KWH; 75-100% EFFIC; 20-250 KWH/t; 0.01-1 MW THERMAL POWER
C         MUCH HIGHER COST BUT MUCH HIGHER ENERGY DENSITY
C         DENSITY: 300 KWH/M3 FOR ICE
C         LIFETIMES: 10-30 YEARS
C
C EFFIC = STORAGE EFFICIENCY (ACCOUNTING FOR CHARGING, DISCHARGING, AND LOSSES)
C         L-I BATTERY CHARGE/DISCHARGE EFFICIENCY 80-90% FROM
C         http://en.wikipedia.org/wiki/Lithium-ion_battery#cite_note-PHEV1-3
C         INITIALLY, CHARGING EFFICIENCY 97-99%; 0 WHEN SATURATED
C $1.29 PER EURO
C
C                         $MIL/MW   $MIL/MW   $/KWH               EFFIC
C            LITHIUM ION    4        2.2  160(f)                85   (80-90)%
C                                          LAZARD 8.0
C                         O&M $22-27.5/KWH  500-750 FOR 6 HRS (2014) 75-85%
C                                          300     FOR 6 HRS (2017) 75-85%
C            REDOX FLOW     4.5      3.0
C            FLYWHEEL       3.1      1.7
C            SODIUM SULFUR  2.0      1.4
C            PUMPED HYDRO   3.3      3.4
C            SENSIBLE HEAT TES (STES)     6.5(d)  (0.13-12.9) 70   (50-90)%(d)
C            UNDERGROUND TES (UTES)       1.0(h,i)(0.07-4.55) 70   (50-90) (d)
C            PCM (E.G., ICE)              38.7(c) (12.9-64.5) 82.5 (75-90) (d)
C             ICE STORAGE                 36.7(a)             82.5 (75-90) (d)
C             ICE STORAGE                 41.6(d)             82.5 (75-90) (d)
C            TCS                          69.7(c) (10.3-129)  87.5 (75-100)(d)
C            MOLTEN NITRATE SALT (SENS)   60.0(f) (56-73)     96   (93-99)
C            MOLTEN NITRATE SALT (LATENT) 16.0(f) (15.3-36)   96   (93-99)
C
C            (a) http://www.kau.edu.sa/Files/320/Researches/52690_22996.pdf (36.7)
C            (b) http://www.missioncriticalmagazine.com/ext/resources/MC/Home/
C                      Files/PDFs/Using_Thermal_Energy_Storage.doc
C            (c) FROM ROBERT REID, STANFORD UTILITIES
C                STANFORD UNIVERSITY $8 MIL IN 1998 FOR ICE COILS + ROTARY SCREW
C                COMPRESSOR CHILLERS + PIPING + REWORKING UNDERGROUND + EST $4 MIL
C                FOR PRE-EXISTING STORAGE TANK (STRAT CHILLED WATER TANK)
C                120,000 TON-HOURS X 3.517 KW/TON = 422,016 KWH
C                1 REFRIGERATION TON (RT) COOLING = 12,000 BTU/HR = 3.517 KW
C                LAT HEAT FREEZ=144 BTU/LB-->1 RT(12,000 BTU)=83.33 LB ICE AT 32F
C                INFLAT 1998->2014 46.2%->$12 MIL->$17.54 MIL/422,040KWH=$41.6/KWH
C                1 KWH=3.41214163 BTU
C                4% ANN ENERGY LOSS IN STORAGE DUE TO HEAT LOSS TO GROUND
C            (d) http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP
C                %20Tech%20Brief%20E17%20Thermal%20Energy%20Storage.pdf
C            (e) Kearney and Associates, Engineering evaluation of a molten salt
C                  HTF in a parabolic trough solar field,
C                  http://www.nrel.gov/csp/troughnet/pdfs/ulf_herrmann_salt.pdf
C                Reddy, R.G. Novel molten salts thermal energy storage for
C                  concentrated solar power generation,
C                  http://energy.gov/sites/prod/files/2014/01/f7/csp_review_
C                  meeting_042413_reddy.pdf
C            (f) http://green.autoblog.com/2013/11/08/li-ion-battery-prices-
C                    headed--down-180-kwh/
C            (g) Nithyanandam, K., and R. Pitchumani, 2014, Cost and performance
C                analysis of concentrating solar power systems with integrated
C                latent thermal energy storage, Energy, 64, 793-810.
C            (h) Gaine (2010) http://arrow.dit.ie/cgi/viewcontent.cgi?article
C                =1007&context=dubencon2
C                $0.055 EURO/kWH = $0.071/kWH2
C            (i) $3.13/kWH = AVG OF $1.71, 4.55/kWh: 1.5-3 KBTU/FT^3;
C                 http://www.igshpa.okstate.edu/membership/members_only/proceed
C                 ings/2011/100611-1030-B-Christopher%20Fox%20-%20Rehau%20-%20
C                 Underground%20Thermal%20Energy%20Storage.pdf
C
C EFFCSP   = ROUND-TRIP EFFICIENCY OF CSP PHASE-CHANGE MATERIAL STORAGE (FRACTION)
C            http://en.wikipedia.org/wiki/Thermal_energy_storage (99%) e
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C             THIS IS ELECTRICITY PRODUCED FROM STEAM IF SOLAR HEAT
C             IS STORED FIRST VERSUS IF IT IS USED IMMEDIATELY FOR STEAM
C             STEAM TURBINE ITSELF IS 75% EFFICIENT
C             https://www.physicsforums.com/threads/why-water-turbine-have-
C              higher-efficiency-then-steam-turbine.272234/
C EFFPHS   = ROUND-TRIP EFFICIENCY OF PUMPED HYDRO (FRACTION ~ 0.8)
C             http://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity
C             http://en.wikipedia.org/wiki/Grid_energy_storage
C EFFPCM   = ROUND-TRIP EFFICIENCY OF PCM-ICE STORAGE (FRACTION)
C EFFCSTES = ROUND-TRIP EFFICIENCY OF ELECTRIC WATER CHILLERS (WATER COOLED STES)
C          = 60-99% WITH WATER CHILLERS AT THE HIGH END AND AIR COOLED AT LOW
C             http://www.utilitydive.com/news/ice-ice-energy-the-hot-market-
C             for-cooled-liquid-energy-storage/408356/
C          = 0.88 = COP / (1 + COP), WHERE COP = 7.33 FROM P. 19 OF
C             https://sustainable.stanford.edu/sites/default/files/documents/
C             SESI-CHP-vs-SHP-%26-CHC.pdf
C          = Qc / Qh = COP / (1+ COP) WHERE
C             COP (COEFFICIENT OF PERFORMANCE) = Qcold/W, WHERE W=WORK=Qhot-Qcold
C             SINCE Qhot = Qcold + W, WHERE Qhot = HEAT TRANSFERRED TO HOT
C             RESERVOIR, Qcold = HEAT COLLECTED FROM COLD RESERVOIR. W=ENERGY
C             ADDED TO SYSTEM.
C EFFHSTES = ROUND-TRIP EFFICIENCY OF ELECTRIC BOILER
C          = 84.5% STANFORD SESE (P. 18) (54546 MMBTU IN; 46096 MMBTU OUT)
C          = 81.3% STANFORD SESI (P. 19) (1293390 MMBTU IN; 1051000 MMBTU OUT)
C             https://sustainable.stanford.edu/sites/default/files/documents/
C             SESI-CHP-vs-SHP-%26-CHC.pdf
C          = 0.7-0.9 FOR HEAT CYCLING (ELECTRICITY TO HEAT)
C          = 0.3-0.6 FOR CONVERTING ELECTRICITY TO HEAT TO ELECTRICITY
C             SINCE STEAM TURBINE HAS 75% EFFICIENCY
C                P.26 http://cdn.intechopen.com/pdfs-wm/42273.pdf
C EFFBAT   = ROUND-TRIP EFFICIENCY OF L-I BATTERY STORAGE (FRACTION)
C          = 0.9 FOR POWERWALL2 https://www.tesla.com/powerwall
C             13.5 KWH; 7 KW PEAK DISCHARGE RATE; 100% DEPTH OF DISCHARGE
C             0.895 FOR POWERPACK 4-H STORAGE https://www.tesla.com/powerpack
C             0.88  FOR POWERPACK 2-H STORAGE
C             232 KWH AC; 58 KW PEAK DISCHARGE RATE; 100% DEPTH DISCHARGE
C EFFHTBAT = ROUND-TRIP EFFICIENCY OF CHARGING+DISCHARGING HEAT BATTERY.
C          = 0.98 FROM RONDO DATASHEET FOR RHB300
C             ASSUMES ELEC RESIST HEATING; RELEASE AS STEAM OR HOT AIR
C EFFUTES  = ROUND-TRIP EFFICIENCY OF UTES STORAGE (FRACTION)
C             WHEN FLUID HEAT PRODUCED COMES FROM EITHER ELECTRICITY OR SUNLIGHT
C             (SINCE SOLAR COLLECTOR EFFICIENCY ALREADY ACCOUNTED FOR IN
C              EFFSOLCOL AND PV/CSP EFFICIENCIES ALREADY ACCOUNTED FOR)
C          = DELIVERED HEAT ONE SEASON/HEATED FLUID PROD FROM HOT FLUID IN ANOTHER
C          = 0.558 FROM YEAR 4 OF TABLE 2 OF
C             SIBBITT ET AL ENERGY PROCEDIA 30, 856, 2012
C             (2460 GJ DELIVERED - 193 GJ ELEC USED) / 4060 GJ PROD IN COLLECTOR
C             (DISTRICT LOOP LOSSES ELIMINATED AS IN YEAR 5)
C             THIS IS THE EFFICENCY OF CONVERTING EXISTING
C             HOT WATER IN ONE SEASON TO END USE HEAT IN ANOTHER SEASON
C EFFTURB  = EFFICIENCY OF STEAM TURBINE (PRODUCING ELECTRICITY FROM HEAT)
C          = 0.75
C             http://www.elliott-turbo.com/TurbineCalculator
C             https://www.physicsforums.com/threads/why-water-turbine-have-
C              higher-efficiency-then-steam-turbine.272234/
C
      EFFCSP   = 0.99
      EFFPHS   = 0.80
      EFFPCM   = 0.825
      EFFCSTES = 0.88
      EFFHSTES = 0.83
      EFFBAT   = 0.895
      EFFHTBAT = 0.98
      EFFUTES  = 0.56
C
C ***************************************************************************
C     PARAMETERS FOR H2 ELECTROLYSIS, COMPRESSION, WATER, STORAGE
C ***************************************************************************
C ELECLYZEN = KWH-CONSUMED/KG-H2-PRODUCED BY ELECTROLYZER
C              53.37 (73.8% EFFICIENT) (JACOBSON ET AL., SCIENCE 2005 - J05)
C              50.0   KWH/KG-H2-PRODUCED BY ELECTROLYZER (78.8 EFFICIENT)
C                     https://www.nrel.gov/docs/fy11osti/50408.pdf
C              41.46  KWH/KG-H2-PRODUCED BY ELECTROLYZER (95% EFFICIENT)
C                     https://www.nature.com/articles/s41467-022-28953-x
C                     https://newatlas.com/energy/hysata-efficient-hydrogen-electrolysis/
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C             40.4   KWH/KG-H2-PRODUCED BY ELECTROLYZER (97.5% EFFICIENT)
C                    https://www.nature.com/articles/s41467-022-28953-x
C COMPRESEN = KWH-CONSUMED/KG-H2-COMPRESSED BY COMPRESSOR
C             5.639 (J05)
C HIHEATH2  = HIGHER HEATING VALUE OF H2 (39.39 KWH/KG-H2=141.8 MJ/KG-H2)
C H2ENERGY  = KWH/KG-H2-PRODUCED-AND-COMPRESSED (=TWH/TG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C             ELECTROLYZER: 41.46 KWH/KG-H2
C             COMPRESSOR:   5.639 KWH/KG-H2 (J05)
C                           3 (2-4) KWH/KG-H2 FOR 350 BAR STORAGE
C                           https://www.nrel.gov/docs/fy14osti/58564.pdf
C             TOTAL:        47.10 KWH/KG-H2 FOR ELECTROLYSIS + COMPRESSION
C
      HIHEATH2  = 39.39
      ELECLYZEN = 41.46
      COMPRESEN =  5.639
      H2ENERGY  = ELECLYZEN + COMPRESEN
C
C H2LOSRAT  = FRACTION OF H2 PRODUCED BY ELECTROLYZER THAT IS LOST
C             DURING TRANSFER TO STORAGE (NOMINALLY 0.003)
C H2CHAREFF = FRACTION OF ENERGY IN H2FC STORAGE
C             NOT LOST DUE TO T&D LOSSES AND LOSSES CHARGING H2 STORAGE
C           = 0.8338: INCLUDES ELECTROLYZER LOSS (0.95 EFF = ELECTROLYZER 0.96
C             EFF X RECTIFIER 0.9896 EFF), COMPRESSOR LOSS
C             (0.8803 EFF) AND LEAKS (0.997 EFF) - JACOBSON 2023 H2-NH3-STEEL PAPER
C             RECTIFIER EFFIC ~0.99 (ABB EST >0.98. ASSUME 0.99 IN 2035)
C             https://library.e.abb.com/public/c99b560b59ed43db8025ab36b67ebdb3/
C                     ABB_Brochure_Hydrogen_A_2021_LowRes.pdf
C             RECTIFIER CONVERTS AC TO DC ELECTRICITY FOR USE IN
C             ELECTROLYZER
C H2DCEFF   = FRACTION OF ENERGY IN H2 STORAGE (BASED ON HHV OF H2) FOR ELECTRICITY
C             NOT LOST DUE TO LOSSES GOING THRU FUEL CELL & INVERTER
C             SUCH LOSSES INCLUDE FUEL CELL LOSS (0.65 EFF),
C           = 0.5362: LATENT HEAT LOSS (0.846 EFF) & DC TO AC INVERTER LOSSES (0.975 EFF)
C             JACOBSON 2023 H2-NH3-STEEL PAPER
C             LATENT HEAT LOSS IS RATIO OF LHV TO HHV OF H2
C             FUEL CELL EFFICIENCY IS FRACTION OF LOWER HEATING VALUE OF
C             H2 CONVERTED TO ELECTRICITY.
C EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C             IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C             CELL EFFIC, ETC.
C
      H2LOSRAT  = 0.003
      H2CHAREFF = (1.-H2LOSRAT) * HIHEATH2 / H2ENERGY
      H2DCEFF   = 0.65 * 0.846  * 0.975
      EFFH2CD   = H2CHAREFF * H2DCEFF
C
C ***************************************************************************
C   2050 NEW+EXISTING INSTALLED MW (NAMEPLATE CAPACITY) RESULTING IN SUPPLY
C                          IN KWWS
C              DATA FROM 50-STATE PLANS (JACOBSON ET AL. 2014)
C     'Intermediate details by state' TAB in 50-States WWS.xlsx file
C     'Table for GATOR-GCMOM' TAB IN 143 countries xlsx file
C         AND 'Additional WWS for grid study' TAB FOR TGWSHEAT
C ***************************************************************************
C TGWONWIND  = NEW+EXISTING INSTALLED GW OF ONSHORE WIND TURBINES
C TGWOFFWIND = NEW+EXISTING INSTALLED GW OF OFFSHORE WIND TURBINES
C TGWRESPV   = NEW+EXISTING INSTALLED GW OF RESIDENTIAL ROOFTOP PV
C TGWCOMPV   = NEW+EXISTING INSTALLED GW OF COMMERCIAL/GOVERNMENT ROOFTOP PV
C TGWUTILPV  = NEW+EXISTING INSTALLED GW OF UTILITY-SCALE PV
C TGWCSPORIG = NEW+EXISTING INSTALLED GW OF CONCENTRATED SOLAR POWER (CSP)
C              ACCOUNTING FOR ANNUAL AVERAGE DEMAND PLUS ADDITIONAL
C              DEMAND NEEDED TO KEEP GRID STABLE.
C TGWGEOEL   = NEW+EXISTING INSTALLED GW OF GEOTHERMAL ELECTRIC POWER
C TGWHYD     = NEW+EXISTING INSTALLED GW OF HYDRPOWER OVER REGION IGRIDUSE
C              BEFORE ADDED TURBINES
C TGWWAVE    = NEW+EXISTING INSTALLED GW OF WAVE POWER
C TGWTIDAL   = NEW+EXISTING INSTALLED GW OF TIDAL POWER
C TGWSHEAT   = NEW+EXISTING INSTALLED GW OF SOLAR THERMAL
C TGWGEOHT   = NEW+EXISTING INSTALLED GW OF GEOTHERMAL HEAT
C TGWINSTREG = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC FOR DEVICE K
C
C SUBTRACT OFF ALASKA AND HAWAII, RESPECTIVELY, FROM U.S. TOTAL FROM 50-STATE PLAN)
C   TO OBTAIN CONUS VALUES. FOR CSP, DO NOT INCLUDE HERE ADDITIONAL CSP FOR STORAGE
C   OR MIRRORS (CSPTURBFAC, CSPCHARFAC). THESE WILL BE ADDED LATER
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```
C
C FOR IFCONUS=1, THESE ARE FINAL VALUES FROM 50-STATE PAPER
C
      IF (IFCONUS.EQ.1) THEN
       TGWONWIND  = (1700.851 -  22.005 - 1.736)
       TGWOFFWIND = ( 780.921 -   7.439 - 1.545)
       TGWRESPV   = ( 379.513 -   0.414 - 2.291)
       TGWCOMPV   = ( 276.508 -   0.242 - 1.320)
       TGWUTILPV  = (2325.575 -   7.882 - 1.268)
       TGWCSPORIG = ( 227.275 -   0.    - 0.441)
       TGWGEOEL   = (  23.251 -   1.188 - 1.321)
       TGWHYD     = (  91.650 -   4.144 - 0.024)
       TGWWAVE    = (  27.036 -   0.668 - 0.173)
       TGWTIDAL   = (   8.823 -   0.414 - 0.153)
       TGWSHEAT   = ( 469.010 -   1.343 - 0.767)
       TGWGEOHT   =  SMAL30
C
C NOTE THAT TGWCSPORIG HERE ACCOUNTS ONLY FOR ANNUAL AVERAGE POWER. ADDITIONAL
C INSTALLED CSP ADDED BELOW WITH CSPTURBFAC
C
      ELSE
       TGWONWIND  = MAX(TGWINSTREG(IGRIDUSE,IONWIND), SMAL30)
       TGWOFFWIND = MAX(TGWINSTREG(IGRIDUSE,IOFFWIND),SMAL30)
       TGWRESPV   = MAX(TGWINSTREG(IGRIDUSE,IRESPV),  SMAL30)
       TGWCOMPV   = MAX(TGWINSTREG(IGRIDUSE,ICOMGVPV),SMAL30)
       TGWUTILPV  = MAX(TGWINSTREG(IGRIDUSE,IUTILPV), SMAL30)
       TGWCSPORIG = MAX(TGWINSTREG(IGRIDUSE,ICSPSTOR),SMAL30)
       TGWGEOEL   = MAX(TGWINSTREG(IGRIDUSE,IGEOEL),  SMAL30)
       TGWHYD     = MAX(TGWINSTREG(IGRIDUSE,IHYDRO),  SMAL30)
       TGWWAVE    = MAX(TGWINSTREG(IGRIDUSE,IWAVE),   SMAL30)
       TGWTIDAL   = MAX(TGWINSTREG(IGRIDUSE,ITIDAL),  SMAL30)
       TGWSHEAT   = MAX(TGWINSTREG(IGRIDUSE,ISOLTHM), SMAL30)
       TGWGEOHT   = MAX(TGWINSTREG(IGRIDUSE,IGEOHT),  SMAL30)
      ENDIF
C
C ***************************************************************************
C  INCREASE THE NUMBER OF STEAM TURBINES IN EACH CSP PLANT IF WANT
C  TO INCREASE DISCHARGE RATE OF HEAT TO ELECTRICITY. THE CHARGE RATE ALREADY
C  EXCEEDS DISCHARGE RATE BY A FACTOR OF ~3.2 DUE TO THE HIGH CAPACITY FACTOR OF
C  CSP (HEAT COLLECTED IS OVERSIZED RELATIVE TO STEAM TURBINE SIZE). THIS
C  FACTOR CAN BE INCREASED WITH CSPCHARFAC. MULTIPLYING
C  TGWCSPORIG BY CSPTURBFAC HERE INREASES DISCHARGE RATE TO CLOSER TO CHARGE RATE
C  ALLOWING CSP TO MEET PEAKING DEMAND MORE READILY, SINCE OTHERWISE, LOTS
C  OF HEAT IS STUCK IN STORAGE WHEN IT IS NEEDED. CSPTURBFAC CAN = CSPCHARFAC.
C  IN THAT CASE, CHARGE RATE = DISCHARGE RATE.
C  COSTS OF ADDITIONAL STORAGE AND ADDITIONAL TURBINE GW ARE ACCOUNTED FOR.
C ***************************************************************************
C CSPTURBFAC = RATIO OF MW OF CSP STEAM TURBINES DESIRED RELATIVE TO MW
C              ORIGINALLY INSTALLED FOR EACH CSP PLANT IN ORDER TO MEET
C              ANNUALLY AVERAGED POWER DEMAND FOR STATE OR COUNTRY
C              BEFORE CONSIDERING THE GRID.
C            = 1.  INDICATES NO ADDITIONAL TURBINE POWER NEEDED TO MATCH DEMAND
C            = 1.6 INDICATES 60% MORE MW OF POWER NEEDED TO MATCH POWER DEMAND
C                  ON GRID THAN NEEDED FOR ANNUALLY AVERAGED POWER DEMAND.
C TGWCSPORIG = EXISTING + NEW GW OF CSP STEAM TURBINES INSTALLED. UPDATED HERE
C              TO INCREASE RATE OF DISCHARGE OF HEAT FROM STORAGE AS ELECTRICITY
C              (DOES NOT INCLUDE TMWCSPADD, WHICH IS WHY IT IS MULT BY CSPTURBFAC)
C TGWCSP     = EXISTING + NEW GW OF CSP STEAM TURBINES INSTALLED. AFTER UPDATE
C CSPDISCH   = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C            = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C              IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C              LESS THAN OR EQUAL TO THE CHARGING RATE (CSPCHARG) OF DIRECT
C              ELECTRICITY PLUS STORAGE BY THE AMOUNT OF STORAGE.
C              COST OF TURBINES IS ACCOUNTED FOR IN AVCAPLO, AVCAPHI
C TWPERGW    = 0.001    TERAWATTS (TW) PER GIGAWATT(GW)
C
      TGWCSP     = TGWCSPORIG * CSPTURBFAC
      CSPDISCH   = TGWCSP     * TWPERGW
C
C ***************************************************************************
C TW WIND & SOLAR INSTALLED IN GATOR-GCMOM TO RESULT IN SUPPLIES IN KWWS
C ***************************************************************************
C TWONSHGAT  = TW ONSHORE WIND INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWOFFSHGAT = TW OFFSHORE WIND INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWWINDGAT  = TW ONSHORE+OFFSHORE WIND INSTALLED WORLDWIDE IN GATOR-GCMOM
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C            = 379,189 5-MW (1,895,945 MW) ONSHORE
C            + 184,603 5-MW (  923,015 MW) OFFSHORE TURBINES
C            = 563,792 5-MW (2,818,960 MW) ONSHORE+OFFSHORE TURBINES
C TWROOFPVG  = TW ALL ROOFTOP PV INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWUTILPVG  = TW ALL UTILITY PV INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWCSPGAT   = TW ALL CSP-MIRROR INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWSHTGAT   = TW ALL SOLAR THERMAL INSTALLED WORLDWIDE IN GATOR-GCMOM
C TGWGATREG  = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC DEVICE K GATOR SIMS
C TWPERGW    = 0.001    TERAWATTS (TW) PER GIGAWATT (GW)
C EGWSHEAT   = EXISTING INSTALLED GW SOLAR HOT WAT/GLYCOL COLLECTORS
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER (NODES 261 AND 260 ON CLEANAIR)
C
      IF (IFCONUS.EQ.1) THEN
       TWONSHGAT  = 1.677111
       TWOFFSHGAT = 0.771937
       TWROOFPVG  = 0.651754
       TWUTILPVG  = 2.316420
       TWCSPGAT   = 0.949754
       TWSHTGAT   = 0.466896
       EGWSHEAT   = 0.
      ELSE
       TWONSHGAT  = MAX(TGWGATREG(IGRIDUSE,IONWIND)   *TWPERGW,SMAL30)
       TWOFFSHGAT = MAX(TGWGATREG(IGRIDUSE,IOFFWIND)  *TWPERGW,SMAL30)
       TWROOFPVG  = MAX((TGWGATREG(IGRIDUSE,IRESPV)
     1            +   TGWGATREG(IGRIDUSE,ICOMGVPV))*TWPERGW,2.*SMAL30)
       TWUTILPVG  = MAX(TGWGATREG(IGRIDUSE,IUTILPV)   *TWPERGW,SMAL30)
       TWCSPGAT   = MAX(TGWGATREG(IGRIDUSE,ICSPSTOR)  *TWPERGW
     1            * CSPSTORGAT,SMAL30)
       TWSHTGAT   = MAX(TGWGATREG(IGRIDUSE,ISOLTHM)   *TWPERGW,SMAL30)
       EGWSHEAT   = EGWINSTREG(IGRIDUSE,ISOLTHM)
      ENDIF
C
C ***************************************************************************
C  CALCULATE RATIOS FOR ADJUSTING INSTALLED CAPACITIES FROM countrystats.dat
C  IN CASE THESE WERE UP-DATED SINCE THE GATOR-GCMOM SIMULATIONS WERE RUN
C  WITH DIFFERENT INSTALLED CAPACITIES. THESE RATIOS SHOULD = 1 IF THERE IS
C  NO DIFFERENCE
C ***************************************************************************
C RATONSHW  = RATIO OF INSTALLED TW ONSHORE WIND ACTUALLY NEEDED TO
C             THAT USED IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C RATOFFSHW = RATIO OF INSTALLED TW OFFSHORE WIND ACTUALLY NEEDED TO
C             THAT USED IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C RATROOFPV = RATIO OF INSTALLED RESID+COMMERC/GOVT ROOF PV (TW) TO THAT USED
C             IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C RATUTILPV = RATIO OF INSTALLED UTILITY SCALE PV (TW) TO THAT USED IN
C             GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C RATSHEAT  = RATIO OF INSTALLED TW SOLAR THERM NEEDED TO THAT USED
C             IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C TGWONWIND  = NEW+EXISTING INSTALLED GW OF ONSHORE WIND TURBINES
C TGWOFFWIND = NEW+EXISTING INSTALLED GW OF OFFSHORE WIND TURBINES
C TGWRESPV   = NEW+EXISTING INSTALLED GW OF RESIDENTIAL ROOFTOP PV
C TGWCOMPV   = NEW+EXISTING INSTALLED GW OF COMMERCIAL/GOVERNMENT ROOFTOP PV
C TGWUTILPV  = NEW+EXISTING INSTALLED GW OF UTILITY-SCALE PV
C TGWSHEAT   = NEW+EXISTING INSTALLED GW OF SOLAR THERMAL HEAT
C TWPERGW   = 0.001 TERAWATTS (TW) PER GIGAWATT(GW)
C
       RATONSHW   = TGWONWIND             * TWPERGW / TWONSHGAT
       RATOFFSHW  = TGWOFFWIND            * TWPERGW / TWOFFSHGAT
       RATROOFPV  = (TGWRESPV + TGWCOMPV) * TWPERGW / TWROOFPVG
       RATUTILPV  = TGWUTILPV             * TWPERGW / TWUTILPVG
       RATSHEAT   = TGWSHEAT              * TWPERGW / TWSHTGAT
C
C ***************************************************************************
C         PV AND CSP EFFICIENCIES USED TO CALCULATE SUPPLY IN GATOR
C ***************************************************************************
C SUNPOWER E20 / 435 W PANEL
C          PMAX                 = 435 W
C          DIMENSIONS           = 2067 MM X 1046 MM X 54 MM
C          PANEL SURFACE AREA   = 2.1621 M^2
C          CELL EFFICIENCY      = 22.5% = ELEC OUTPUT OF CELL / INCIDENT ENERGY
C          PANEL EFFICIENCY     = 20.1% = PMAX / (ONESUN * PANEL SURF AREA)
C          TEMP COEF FOR POWER  = -0.38%/K
C          NORMAL OPER CELL TEMP= 45 C (EQUIV TO 25 C AIR TEMPERATURE)
C          WALKING AREA IN FARM = 0.5 * PANEL SURFACE AREA
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C
C ONESUN    = 1000 W M-2 = SOLAR FLUX AT RATED POWER OF SOLAR PANEL
C PPANEL    = SOLAR PANEL RATED POWER (W) AT 1000 W/M2 SOLAR INTENSITY
C             A 160 W PANEL RATED BY MANUFACTURER IS 142 W RATED BY CEC
C PPANELMW  = SOLAR PANEL RATED POWER (MW) AT 1000 W/M2 SOLAR INTENSITY
C PVSURFA   = SURFACE AREA (M2) OF SOLAR PANEL (NOT INCLUDING WALKING AREA)
C APANEL    = AREA OF PV SOLAR PANEL INCLUDING WALKING AREA (M2)
C PANEFFIC  = PANEL EFFICIENCY (FRACTION) = PPANEL / (ONESUN * PVSURFA)
C AREAPV    = U.S. AREA (M2) OCCUPITED BY SOLAR PV PANELS (NOT INC SPACING)
C             IN GATOR-GCMOM
C TWROOFPVG = TW ALL ROOFTOP PV INSTALLED WORLDWIDE IN GATOR-GCMOM
C TWUTILPVG = TW ALL UTILITY PV INSTALLED WORLDWIDE IN GATOR-GCMOM
C
      ONESUN   = 1000.
      PPANEL   = 435.
      PPANELMW = PPANEL * 1.0E-6
      PVSURFA  = 2.1621
      APANEL   = PVSURFA * 1.5
      PANEFFIC = PPANEL / (ONESUN * PVSURFA)
      AREAPV   = PVSURFA * (TWROOFPVG+TWUTILPVG) * 1.0E+06 / PPANELMW
C
C CSPEFFIC  = CSP EFFICIENCY (FRACTION) = FRAC OF INCOM SOLAR CONVERTED TO ELEC
C           = CSPSTEFF * CSPREFEF
C CSPSTEFF  = EFFICIENCY OF STEAM PLANT (28.72%) = ELECTRICITY PRODUCED
C             PER UNIT OF ENERGY REACHING SOLAR TOWER
C             http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C CSPEFFIC  = CSP EFFICIENCY (FRACTION) = FRAC OF INCOM SOLAR CONVERTED TO ELEC
C           = CSPSTEFF * CSPREFEF
C CSPSTEFF  = POWER EFFICIENCY OF STEAM PLANT (28.72%) = ELECTRICITY PRODUCED
C             PER UNIT OF ENERGY REACHING SOLAR TOWER
C             28.72%: http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C             15-38%: http://www.nrel.gov/docs/fy11osti/50686.pdf
C CSPREFEF  = REFLECTION EFFICIENCY (ACCOUNTS FOR ABSORPTION LOSSES TOO) OF
C             MIRRORS TO CENTRAL TOWER (55%). THUS 55% OF INCIDENT LIGHT REACHES
C             CENTRAL TOWER FROM MIRRORS)
C             http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C CSPMIRROR = AREA (M2) OF MIRRORS IN ONE 100-MW CSP POWER PLANT
C             IVANPAH (377 MW NET NAMEPLATE CAPACITY)
C             HAS 173,500 HELIOSTATS, EACH WITH TWO MIRRORS. ONE MIRROR
C             HAS SURFACE AREA OF 7.02 M^2. THE TOTAL MIRROR AREA IS
C             2,437,144 M^2, GIVING A MIRROR AREA OF 646,457 M^2 PER 100 MW
C             OR 0.646 KM2 PER 100 MW INSTALLED
C             http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C             50-STATE PLANS IN 'ENVIRONMENTAL IMPACTS' TAB
C             ASSUME 1.9-2.4 KM2/100-MW PLANT
C CSPLAND   = AREA (M2) OF LAND FOR ONE 100-MW CSP POW PLANT (AVG OF 1.9-2.43 KM2)
C             IVANPAH IS 3500 ACRES = 14.16 KM^2 = 3.76 KM^2 PER 100-MW
C             http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C CSPCFAC   = CAPACITY FACTOR OF CSP PLANT (NO STORAGE) = 31.4% FOR IVANPAH
C             http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility
C             377 MW x 8760 HRS/YR x 0.314 = 1.04 TWh/YR
C             COMPARE WITH
C             2,437,144 M^2 HELIOSTATS x 7.4 kWh/m2/day x 365 DAYS/YR
C             x 0.55 (CSPREFEF) x 0.2872 (CSPSTEFF) = 1.04 TWh/YR
C             --> CSPCFACACCOUNTS FOR EFFICIENCY LOSS OF STEAM PLANT
C AREACSP   = U.S. AREA (M2) OCCUPITED BY CSP MIRRORS (NOT INC SPACING)
C TWCSPGAT  = TW ALL CSP INSTALLED WORLDWIDE IN GATOR-GCMOM
C STURBCOSL = LOW STEAM TURBINE INSTALLED COST ($MIL/MW)
C STURBCOSM = MEAN STEAM TURBINE INSTALLED COST ($MIL/MW)
C STURBCOSH = HIGH STEAM TURBINE INSTALLED COST ($MIL/MW)
C           = $0.765 MIL ($0.43-1.1)MIL/MW     O&M < $0.005/KWH
C             http://www.nrel.gov/docs/fy11osti/50686.pdf
C
      CSPSTEFF  = 0.2872
      CSPREFEF  = 0.55
      CSPEFFIC  = CSPSTEFF * CSPREFEF
      CSPMIRROR = 646457.
      CSPLAND   = 2.17E+06
      CSPCFAC   = 0.314
      AREACSP   = CSPMIRROR * TWCSPGAT * 1.0E+06 / 100.
      STURBCOSL = 0.43
      STURBCOSH = 1.10
      STURBCOSM = 0.5 * (STURBCOSL + STURBCOSH)
C
C EFFSOLCOL = EFFICIENCY OF SOLAR COLLECTOR FOR HOT WATER/GLYCOL
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C           = ENERGY IN HOT FLUID DIVIDED BY INCIDENT SOLAR RADIATION
C           = 0.34 FROM TABLE 2 OF SIBBITT ET AL ENERGY PROCEDIA 30, 856, 2012
C
      EFFSOLCOL = 0.34
C
      WRITE(IOUT,164) PANEFFIC, CSPEFFIC, AREAPV*1E-6,
     1              AREACSP*1E-6, EFFSOLCOL
 164  FORMAT('PANEFFIC    CSPEFFIC      AREAPV(KM2) ',
     1       '  AREACSP(KM2)   EFFSOLCOL ',/,2(0PF12.4),3(0PF14.4)/)
C
C ***************************************************************************
C SCALE INSTALLED CAPACITIES BY FACTOR TO TEST WHETHER INCREASING INSTALLED
C CAPACITY (AND CORRESPONDING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY)
C ***************************************************************************
C FACONWIN  = FACTOR TO MULTIPLY DELIVERED ONSHORE WIND BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACOFFWIN = FACTOR TO MULTIPLY DELIVERED OFFSHORE WIND BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACUTILPV = FACTOR TO MULTIPLY DELIVERED UTILITY PV BY TO TEST WHETHER
C             INCREASING OUTPUT IMPROVES MATCHING DEMAND WITH SUPPLY.
C FACSHT    = FACTOR TO MULTIPLY DELIVERED SOLAR THERMAL BY TO TEST WHETHER
C             INCREASING OUTPUT & NAMEPLATE CAPACITY IMPROVES MATCHING
C             DEMAND WITH SUPPLY.
C PANEFFIC  = PANEL EFFICIENCY (FRACTION) = PPANEL / (ONESUN * PVSURFA)
C EGWSHEAT  = EXISTING INSTALLED GW SOLAR HOT WAT/GLYCOL COLLECTORS
C             ENSURE NOT TO GO BELOW EXISTING SOLAR THERMAL
C TGWSHEAT  = NEW+EXISTING INSTALLED GW OF SOLAR THERMAL
C FACRESPV  = FACTOR TO MULTIPLY NAMEPLATE CAPACITY OF RES ROOF PV HERE
C             TO IMPROVE MATCHING DEMAND WITH SUPPLY.
C FACCOMPV  = FACTOR TO MULTIPLY NAMEPLATE CAPACITY OF COM/GOV ROOF PV HERE
C             TO IMPROVE MATCHING DEMAND WITH SUPPLY.
C FACROOFPV = WEIGHTED AVG VALUE OF FACRESPV AND FACCOMPV
C             USED TO MULTIPLY DELIVERED TOTAL ROOFTOP PV FROM
C             GATOR-GCMOM BY
C SUMGWPV   = GW OF RES + COMM/GOVT ROOFTOP PV BEFORE ADJUSTMENTS
C
      SUMGWPV   =  TGWRESPV + TGWCOMPV
      FACROOFPV = (FACRESPV*TGWRESPV + FACCOMPV*TGWCOMPV) / SUMGWPV
C
      TGWONWIND  = TGWONWIND  * FACONWIN
      TGWOFFWIND = TGWOFFWIND * FACOFFWIN
      TGWRESPV   = TGWRESPV   * FACRESPV
      TGWCOMPV   = TGWCOMPV   * FACCOMPV
      TGWUTILPV  = TGWUTILPV  * FACUTILPV
C
      IF (TGWSHEAT.GT.0.) THEN
       FACSHT     = MAX(EGWSHEAT / TGWSHEAT, FACSHT)
       TGWSHEAT   = TGWSHEAT * FACSHT
      ENDIF
C
C TGWTOTAL = TOTAL (GW) INSTALLED NAMEPLATE CAPACITY OF ALL NEW PLUS
C            EXISTING 2050 WWS ELECTRIC POWER GENERATORS (DON'T INCLUDE
C            HEAT: TGWSHEAT + TGWGEOHT)
C
      TGWTOTAL = TGWONWIND + TGWOFFWIND + TGWRESPV + TGWCOMPV
     1         + TGWUTILPV + TGWCSP     + TGWGEOEL + TGWHYD
     1         + TGWWAVE   + TGWTIDAL
C
C ***************************************************************************
C TOTONWND  = TOTAL NEW+EXISTING INSTALLED ONSHORE WIND CAPACITY (TW)
C TOTOFFWND = TOTAL NEW+EXISTING INSTALLED OFFSHORE WIND CAPACITY (TW)
C TOTROOFPV = TOTAL NEW+EXISTING INSTALLED RES + COMM/GOV ROOF PV CAPACITY (TW)
C TOTUTILPV = TOTAL NEW+EXISTING INSTALLED UTILITY SCALE PV CAPACITY (TW)
C TOTCSP    = TOTAL NEW+EXISTING INSTALLED CSP INSTALLED CAPACITY (TW)
C TOTHYDRO  = TOTAL NEW+EXISTING INSTALLED HYDROELECTRIC CAPACITY (TW)
C           = HYDISCHTW = PEAK DISCHARGE RATE OF HYDRO (TW). INCLUDES ANY
C             HYDRO TURBINES ADDED TO INCREASE PEAK DISCHARGE RATE.
C TOTWAVE   = TOTAL NEW+EXISTING INSTALLED WAVE CAPACITY (TW)
C TOTGEOEL  = TOTAL NEW+EXISTING INSTALLED GEOTHERMAL ELEC POWER CAPACITY (TW)
C TOTTID    = TOTAL NEW+EXISTING INSTALLED TIDAL CAPACITY (TW)
C TOTSHEAT  = TOTAL NEW+EXISTING INSTALLED SOLAR THERMAL INSTALLED CAPACITY (TW)
C TOTGHEAT  = TOTAL NEW+EXISTING INSTALLED GEOTHERMAL HEAT INSTALLED CAPAC (TW)
C TGWHYD    = NEW+EXISTING INSTALLED GW OF HYDRPOWER OVER REGION IGRIDUSE
C             BEFORE ADDED TURBINES
C TGWWAVE   = NEW+EXISTING INSTALLED GW OF WAVE POWER
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```
C TWPERGW   = 0.001 TERAWATTS (TW) PER GIGAWATT(GW)
C
      TOTONWND   = TGWONWIND   * TWPERGW             + SMAL30
      TOTOFFWND  = TGWOFFWIND  * TWPERGW             + SMAL30
      TOTROOFPV  = (TGWRESPV + TGWCOMPV) * TWPERGW   + SMAL30
      TOTUTILPV  = TGWUTILPV   * TWPERGW             + SMAL30
      TOTCSP     = TGWCSP      * TWPERGW             + SMAL30
      TOTHYDRO   = TGWHYD      * TWPERGW * HPTURBRAT + SMAL30
      TOTWAVE    = TGWWAVE     * TWPERGW             + SMAL30
      TOTGEOEL   = TGWGEOEL    * TWPERGW             + SMAL30
      TOTTID     = TGWTIDAL    * TWPERGW             + SMAL30
      TOTSHEAT   = TGWSHEAT    * TWPERGW             + SMAL30
      TOTGHEAT   = TGWGEOHT    * TWPERGW             + SMAL30
C
C EGWONWIND  = CONUS EXISTING INSTALLED GW OF ONSHORE WIND TURBINES
C EGWOFFWIND = CONUS EXISTING INSTALLED GW OF OFFSHORE WIND TURBINES
C EGWRESPV   = CONUS EXISTING INSTALLED GW OF RESIDENTIAL PV
C EGWCOMPV   = CONUS EXISTING INSTALLED GW OF COMMERCIAL/GOVERNMENT PV
C EGWUTILPV  = CONUS EXISTING INSTALLED GW OF UTILITY-SCALE PV
C EGWCSP     = CONUS EXISTING INSTALLED GW OF CSP
C EGWGEO     = CONUS EXISTING INSTALLED GW OF GEOTHERMAL POWER
C EGWHYD     = CONUS EXISTING INSTALLED GW OF HYDROELECTRIC POWER
C EGWWAVE    = CONUS EXISTING INSTALLED GW OF WAVE POWER
C EGWTIDAL   = CONUS EXISTING INSTALLED GW OF TIDAL POWER
C EGWSHEAT   = CONUS EXISTING INSTALLED GW SOLAR HOT WAT/GLYCOL COLLECTORS
C EGWINSTREG = GW-SUM OVER REG J, 2014 EXIST NAMEPL CAPAC FOR DEVICE K
C
C SUBTRACT OFF ALASKA AND HAWAII, RESPECTIVELY, FROM U.S. TOTAL FROM 50-STATE PLAN
C   TO OBTAIN CONUS VALUES
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER
C   FROM 'Intermediate details by state' TAB in 50-States WWS.xlsx file
C
      IF (IFCONUS.EQ.1) THEN
       EGWONWIND  = 61.032 - 0.062  - 0.206
       EGWOFFWIND =  0.
       EGWRESPV   =  3.550 - 0.     - 0.095
       EGWCOMPV   =  1.775 - 0.     - 0.0475
       EGWUTILPV  =  1.775 - 0.     - 0.0475
       EGWCSP     =  0.
       EGWGEOEL   =  2.406 - 0.     - 0.031
       EGWHYD     = 87.862 - 0.4141 - 0.024
       EGWWAVE    =  0.
       EGWTIDAL   =  0.
       EGWSHEAT   =  0.
       EGWGEOHT   =  0.
      ELSE
       EGWONWIND  = EGWINSTREG(IGRIDUSE,IONWIND)
       EGWOFFWIND = EGWINSTREG(IGRIDUSE,IOFFWIND)
       EGWRESPV   = EGWINSTREG(IGRIDUSE,IRESPV)
       EGWCOMPV   = EGWINSTREG(IGRIDUSE,ICOMGVPV)
       EGWUTILPV  = EGWINSTREG(IGRIDUSE,IUTILPV)
       EGWCSP     = EGWINSTREG(IGRIDUSE,ICSPSTOR)
       EGWGEOEL   = EGWINSTREG(IGRIDUSE,IGEOEL)
       EGWHYD     = EGWINSTREG(IGRIDUSE,IHYDRO)
       EGWWAVE    = EGWINSTREG(IGRIDUSE,IWAVE)
       EGWTIDAL   = EGWINSTREG(IGRIDUSE,ITIDAL)
       EGWSHEAT   = EGWINSTREG(IGRIDUSE,ISOLTHM)
       EGWGEOHT   = EGWINSTREG(IGRIDUSE,IGEOHT)
      ENDIF
C
C EGWTOTAL = (GW) INSTALLED NAMEPLATE CAPACITY OF PRE-EXISTING WWS
C             ELECTRIC POWER GENERATORS (DON'T INCLUDE
C             HEAT: EGWSHEAT + EGWGEOHT)
C
      EGWTOTAL = EGWONWIND + EGWOFFWIND + EGWRESPV + EGWCOMPV
     1         + EGWUTILPV + EGWCSP     + EGWGEOEL + EGWHYD
     1         + EGWWAVE   + EGWTIDAL
C
C AGWONWIND  = NEW INSTALLED GW OF ONSHORE WIND TURBINES
C AGWOFFWIND = NEW INSTALLED GW OFFSHORE WIND TURBINES
C AGWRESPV   = NEW INSTALLED GW RESIDENTIAL ROOFTOP PV
C AGWCOMPV   = NEW INSTALLED GW COMMERCIAL/GOVERNMENT ROOFTOP PV
C AGWUTILPV  = NEW INSTALLED GW UTILITY-SCALE PV
C AGWCSP     = NEW INSTALLED GW CONCENTRATED SOLAR POWER (CSP)
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C AGWGEOEL   = NEW INSTALLED GW GEOTHERMAL FOR ELECTRICITY
C AGWHYD     = NEW INSTALLED GW HYDROELECTRIC POWER BEFORE ADDED TURBINES
C AGWWAVE    = NEW INSTALLED GW WAVE POWER
C AGWTIDAL   = NEW INSTALLED GW TIDAL POWER
C AGWSHEAT   = NEW INSTALLED GW SOLAR THERMAL HEAT
C AGWGEOHT   = NEW INSTALLED GW GEOTHERMAL FOR HEAT
C
      AGWONWIND  = TGWONWIND  - EGWONWIND
      AGWOFFWIND = TGWOFFWIND - EGWOFFWIND
      AGWRESPV   = TGWRESPV   - EGWRESPV
      AGWCOMPV   = TGWCOMPV   - EGWCOMPV
      AGWUTILPV  = TGWUTILPV  - EGWUTILPV
      AGWCSP     = TGWCSP     - EGWCSP
      AGWGEOEL   = TGWGEOEL   - EGWGEOEL
      AGWHYD     = TGWHYD     - EGWHYD
      AGWWAVE    = TGWWAVE    - EGWWAVE
      AGWTIDAL   = TGWTIDAL   - EGWTIDAL
      AGWSHEAT   = TGWSHEAT   - EGWSHEAT
      AGWGEOHT   = TGWGEOHT   - EGWGEOHT
C
C ***************************************************************************
C
C ***************************************************************************
C            DELIVERED 2050 POWER FROM NON-WIND, NON-SOLAR SOURCES
C                 AFTER TRANSMISSION & DISTRIBUTION LOSSES
C                       ***NOT NAMEPLATE CAPACITIES***
C  GWe FROM 'INTERMEDIATE DETAILS BY STATE' TAB IN 50-States WWS.xlsx FILE
C ***************************************************************************
C CURGEOEL = 2050 REGIONAL GEOTHERMAL DELIV ELECTRIC POWER AFTER T&D LOSSES (TW)
C CURHYD   = 2050 REGIONAL HYDROELECTRIC DELIVERED POWER AFTER T&D LOSSES (TW)
C CURWAV   = 2050 REGIONAL WAVE DELIVERED POWER AFTER T&D LOSSES(TW)
C CURTID   = 2050 REGIONAL TIDAL DELIVERED POWER AFTER T&D LOSSES (TW)
C CURGEOHT = 2050 REGIONAL GEOTHERMAL HEAT DELIVERED AFTER T&D LOSSES (TW)
C SUPGWREG = GW-SUM OVER REG J, 2050 END-USE POWER SUPPLIED BY DEVICE K
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER

      IF (IFCONUS.EQ.1) THEN
       CURGEOEL = (19.81 - 1.01 - 1.13) * TWPERGW
       CURHYD   = (47.84 - 2.16 - 0.01) * TWPERGW
       CURTID   = ( 2.17 - 0.14 - 0.04) * TWPERGW
       CURWAV   = ( 5.85 - 0.14 - 0.04) * TWPERGW
       CURGEOHT = 0.
      ELSE
       CURGEOEL = SUPGWREG(IGRIDUSE,IGEOEL) * TWPERGW
       CURHYD   = SUPGWREG(IGRIDUSE,IHYDRO) * TWPERGW
       CURTID   = SUPGWREG(IGRIDUSE,ITIDAL) * TWPERGW
       CURWAV   = SUPGWREG(IGRIDUSE,IWAVE)  * TWPERGW
       CURGEOHT = SUPGWREG(IGRIDUSE,IGEOHT) * TWPERGW
C
C FRACLOAD = APPROXIMATE FRACTION OF TOTAL LOAD MET BY ENERGY TECHNOLOGY
C FLOADREG = FRAC 2050 END USE ELEC POWER FROM EACH 1..MXCAP DEVICE IN REGION
C            ALREADY CALCULATED FOR IFCONUS=1 IN DATA STATEMENT
C
       DO I         = 1, MXCAP
        FRACLOAD(I) = FLOADREG(IGRIDUSE,I)
       ENDDO
      ENDIF
C
C ***************************************************************************
C          CAPITAL COSTS AVERAGED BETWEEN 2013 AND 2050 IN 2013 DOLLARS
C     FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C                               FROM M. DELUCCHI
C ***************************************************************************
C CAP COST ($MIL/MW)     LOW         MEDIUM      HIGH
C ONSHORE WIND     1     1.27535     1.48774     1.70012
C OFFSHORE WIND    2     2.69279     3.76996     4.84713
C RES ROOF PV      3     2.71462     3.21983     3.72505
C COMM/GOVT PV     4     2.20509     2.44463     2.68417
C UTILITY PV       5     1.43572     1.55650     1.67729
C CSP-WITH-STORAGE 6     4.87758     5.74921     6.62084
C CSP-NO-STORAGE   7     2.77653     3.18126     3.58599
C GEOTHERMAL       8     2.49487     4.19043     5.88598
C HYDROELECTRIC    9     2.39540     2.82170     3.24800
C TIDAL           10     3.71642     4.30233     4.88824
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C WAVE            11     6.08137     6.81166     7.54196
C
C JACOBSON ET AL. (2015) FROM M. DELUCCHI (INCLUDES TRANSMISSION)
C  CSP - NO STORAGE IVANPAH       $5.6  MILLION/MW = $2.2 BIL / 392 MWW
C      - NO STORAGE PS10 SPAIN    $4.2  MILLION/MW = $360 MIL / 11 MW
C      - NO STORAGE PS20 SPAIN    $5.5  MILLION/MW = $109.8 MIL / 20 MW
C      - NO STORAGE SOLNOVA SPAIN $3.66 MILLION/MW = $548.92 MIL / 150 MW
C
C CAP2019LO = 2013 LOW CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEO
C             HYDRO  TIDAL   WAVE  SOLTHERM
C             CSPNOST HAS $2.42 MIL/MW SUBTRACTED TO REMOVE STORAGE COST
C             ASSUME SOLAR THERMAL SAME AS UTILITY PV
C CAP2019HI = 2013 HI CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEO
C             HYDRO  TIDAL   WAVE  SOLTHERM
C             ASSUME SOLAR THERMAL SAME AS UTILITY PV
C CAP2050LO = 2050 LOW CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEO
C             HYDRO  TIDAL   WAVE  SOLTHERM
C             ASSUME SOLAR THERMAL SAME AS UTILITY PV
C CAP2050HI = 2050 HI CAPITAL COST OF ENERGY SOURCES ($MIL/MW-INSTALLED)
C             FROM 50-STATE 50-state-WWS.xlsx 'Cost of Delivered Electricity' TAB
C             ONWIND OFFWIND RESPV COMPV UTILPV CSPSTOR CSPNOSTOR GEO
C             HYDRO  TIDAL   WAVE  SOLTHERM
C             ASSUME SOLAR THERMAL SAME AS UTILITY PV
C PRINFLATE = INFLATES 2012 PRICES TO 2013 DOLLARS
C IONWIND.. = 1..MXCAP INDEX NUMBER CORRESPONDING TO EACH GENERATOR TYPE
C TDLOSLO   = LO TRANSMISSION & DISTRIBUTION LOSS (FRACTION) OF OUTPUT ELECTRICITY
C             THIS WILL INCLUDE SHORT- AND LONG-DISTANCE TRANSMISSION LOSSES
C TDLOSHI   = HI TRANSMISSION & DISTRIBUTION LOSS (FRACTION) OF OUTPUT ELECTRICITY
C FRACLOAD  = APPROXIMATE FRACTION OF TOTAL LOAD MET BY ENERGY TECHNOLOGY
C TDLOSS    = TRANSMISSIO & DISTRIB LOSS (FRACTION) WEIGHTED BY ESTIMATED
C             END USE POWER BY GENERATOR. ACCOUNTS FOR SHORT & LONG DISTANCE
C           = 0.0707 BASED ON CALCULATION HERE
C
C ***************************************************************************
C   CALC MEAN SHORT+LONG-DISTANCE T&D LOSSES AND CAPITAL COSTS PER GENERATOR
C ***************************************************************************
C AVCAPLO  = AVERAGE (2013 TO 2050) LOW CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPMN  = AVERAGE (2013 TO 2050) MEAN CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPHI  = AVERAGE (2013 TO 2050) HI CAP COST PER GENERATOR ($TRIL/MW)
C TDLOSMN  = MEAN TRANSMISSIO & DISTRIB LOSS (FRACTION) FOR EACH GENERATOR
C            ACCOUNTS FOR SHORT & LONG DISTANCE
C TDEFFMN  = 1-TDLOSMN = TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C TDRATMN  = TDLOSMN / TDEFFMN. MULT ENERGY (TWH) DELIVERED AFTER T&D LOSSES
C            BY TDRATMN TO OBTAIN T&D ENERGY LOSS (TWH)
C SDTRCOSM = MEAN SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C DECOMLO  = LOW DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMMN  = MEAN DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMHI  = HIGH DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMISL = WEIGHTED AVG LOW  DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C DECOMISM = WEIGHTED AVG MEAN DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C DECOMISH = WEIGHTED AVG HIGH DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C
      DECOMISL      = 0.
      DECOMISM      = 0.
      DECOMISH      = 0.
      FRCENDUSE     = 0.
      TDLOSS        = 0.
      DO I          = 1, MXCAP
       AVCAPLO(  I) = PRINFLATE * (CAP2019LO(I)+CAP2050LO(I)) / 2.0E+06
       AVCAPHI(  I) = PRINFLATE * (CAP2019HI(I)+CAP2050HI(I)) / 2.0E+06
       AVCAPMN(  I) = (AVCAPLO(  I) + AVCAPHI(  I)) / 2.
       OANDMMN(  I) = (OANDMLO(  I) + OANDMHI(  I)) / 2.
       DECOMMN(  I) = (DECOMLO(  I) + DECOMHI(  I)) / 2.
       SDTRCOSM( I) = (SDTRCOSL(I)  + SDTRCOSH( I)) / 2.
       YEARLIFEM(I) = (YEARLIFEL(I) + YEARLIFEH(I)) / 2.
       TDLOSMN(  I) = 0.5 * (TDLOSLO(I) + TDLOSHI(I))
       TDEFFMN(  I) = 1. - TDLOSMN(I)
       TDRATMN(  I) = TDLOSMN(I) / TDEFFMN(I)
       DECOMISL     = DECOMISL  + FRACLOAD(I) * DECOMLO(I)
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       DECOMISM     = DECOMISM  + FRACLOAD(I) * DECOMMN(I)
       DECOMISH     = DECOMISH  + FRACLOAD(I) * DECOMHI(I)
       TDLOSS       = TDLOSS    + FRACLOAD(I) * TDLOSMN(I)
       FRCENDUSE    = FRCENDUSE + FRACLOAD(I)
      ENDDO
C
C TDLOSS   = TRANSMISSIO & DISTRIB LOSS (FRACTION) WEIGHTED BY ESTIMATED
C            END USE POWER BY GENERATOR. ACCOUNTS FOR SHORT & LONG DISTANCE
C          = 0.0707 BASED ON CALCULATION HERE
C
      TDLOSS      = TDLOSS / FRCENDUSE
C
C ***************************************************************************
C             2050 END-USE 50-STATE U.S. POWER DEMAND USING WWS
C              THESE ARE LOADS USED AFTER T&D AND STORAGE LOSSES
C     'WWS, BAU end-use TW by state' TAB IN 50-States WWS.xlsx FILE
C ***************************************************************************
C BLOADRES = 50-STATE 2050 RESID WWS LOAD: 0.2825 TW
C             ALASKA                      -0.0008
C             HAWAII                      -0.0004
C             CONUS                        0.2813
C BLOADCOM = 2050 COMMERCIAL     WWS LOAD: 0.2955 TW
C             ALASKA                      -0.0016
C             HAWAII                      -0.0008
C             CONUS                        0.2931
C BLOADIND = 2050 INDUSTRIAL     WWS LOAD: 0.7166 TW
C             ALASKA                      -0.0096
C             HAWAII                      -0.0012
C             CONUS                        0.7058
C BLOADTRA = 2050 TRANSPORTATION WWS LOAD: 0.2964 TW
C             ALASKA                      -0.0025
C             HAWAII                      -0.0013
C             CONUS                        0.2926
C ------------------------------------------------
C TOTAL:                                   1.5910 TW
C             ALASKA                      -0.0145
C             HAWAII                      -0.0037
C             CONUS                        1.5728
C
C TLOADSUM = SUM OF TLOADSEC (GW) AMONG COUNTRIES IN EACH J=1..NUMGRIDS REGION
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER
C                LOAD FOR 48 CONUS STATES ONLY (SUBTRACT ALASKA/HAWAII)
C
      IF (IFCONUS.EQ.1) THEN
       BLOADRES  = 0.2825 - 0.0008 - 0.0004
       BLOADCOM  = 0.2955 - 0.0016 - 0.0008
       BLOADIND  = 0.7166 - 0.0096 - 0.0012
       BLOADTRA  = 0.2964 - 0.0025 - 0.0013
       BLOADAGF  = 0.
       BLOADOTH  = 0.
      ELSE
       BLOADRES  = TLOADSUM(IGRIDUSE,IRESID) * TWPERGW
       BLOADCOM  = TLOADSUM(IGRIDUSE,ICOMM)  * TWPERGW
       BLOADIND  = TLOADSUM(IGRIDUSE,IIND)   * TWPERGW
       BLOADTRA  = TLOADSUM(IGRIDUSE,ITRAN)  * TWPERGW
       BLOADAGF  = TLOADSUM(IGRIDUSE,IAGFF)  * TWPERGW
       BLOADOTH  = TLOADSUM(IGRIDUSE,IOTH)   * TWPERGW
      ENDIF
C
C TLOAD2050 = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C             (SINCE BLOADRES... CALCULATED IN SPREADSHEET ASSUMING
C              ALL HEATING HAS BEEN CONVERTED TO HEAT PUMPS)
C
      TLOAD2050 = BLOADRES+BLOADCOM+BLOADIND+BLOADTRA+BLOADAGF+BLOADOTH
C
C ***************************************************************************
C DETERMINE ELECTRIC POWER LOADS NEEDED FOR H2 PRODUCTION/COMPRESSION/STORAGE
C    'Efficiency, upstream, electrify' TAB IN '50-States WWS.xlsx' FILE
C ***************************************************************************
C FRACREH2 = FRACT OF RESIDENTIAL ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACCOH2 = FRACT OF COMMERCIAL ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACTRH2 = FRACT OF TRANSPORT ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C FRACINH2 = FRACT OF INDUSTRY ELEC GOING TO H2 ELECTROLYSIS/COMPRESS/STORAGE
C             FROM 50-STATE PLAN
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C TWHH2RE  = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR
C            RESIDENTIAL SECTOR FROM 2050 50-STATE PLAN
C TWHH2CO  = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR
C            COMMERCIAL SECTOR FROM 2050 50-STATE PLAN
C TWHH2TR  = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR TRANSPORT
C            FROM 2050 50-STATE PLAN
C TWHH2IN  = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR INDUSTRY
C            FROM 2050 50-STATE PLAN
C BLOADRES  = 2050 RESIDENTIAL      WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADCOM  = 2050 COMMERCIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADIND  = 2050 INDUSTRIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADTRA  = 2050 TRANSPORTATION   WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADAGF  = 2050 AG/FORESTRY/FISH WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADOTH  = 2050 OTHER            WWS LOAD (TW) AFTER HEAT PUMPS
C TWHH2TOT = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C            THIS NUMBER ACCOUNTS FOR LEAKED HYDROGEN
C            THIS NUMBER IS AFTER T&D LOSSES, SO T&D LOSSES MUST BE ADDED TO THESE
C FRCH2REG = FRACTION OF END-USE POWER DEMAND EACH 1..MXSECTOR SECTOR
C            IN EACH 1..NUMGRIDS GRID GOING TO H2 ELECTROL/COMPRESSION/STORAGE
C
C FOR IFCONUS=1: FINAL VALUES FROM 50-STATE PAPER
C
      IF (IFCONUS.EQ.1) THEN
       FRACREH2 = 0.
       FRACCOH2 = 0.
       FRACINH2 = 0.05717
       FRACTRH2 = 0.47792
       FRACAGH2 = 0.
       FRACOTH2 = 0.
      ELSE
       FRACREH2 = FRCH2REG(IGRIDUSE,IRESID)
       FRACCOH2 = FRCH2REG(IGRIDUSE,ICOMM)
       FRACINH2 = FRCH2REG(IGRIDUSE,IIND)
       FRACTRH2 = FRCH2REG(IGRIDUSE,ITRAN)
       FRACAGH2 = FRCH2REG(IGRIDUSE,IAGFF)
       FRACOTH2 = FRCH2REG(IGRIDUSE,IOTH)
      ENDIF
C
C HRSPYR = AVERAGE NUMBER OF HOURS PER YEAR DURING WHOLE SIMULATION
C
      TWHH2RE  = BLOADRES * HRSPYR * FRACREH2
      TWHH2CO  = BLOADCOM * HRSPYR * FRACCOH2
      TWHH2IN  = BLOADIND * HRSPYR * FRACINH2
      TWHH2TR  = BLOADTRA * HRSPYR * FRACTRH2
      TWHH2AG  = BLOADAGF * HRSPYR * FRACAGH2
      TWHH2OT  = BLOADOTH * HRSPYR * FRACOTH2
      TWHH2TOT = TWHH2RE+TWHH2CO+TWHH2IN+TWHH2TR+TWHH2AG+TWHH2OT
C
C ***************************************************************************
C     PARAMETERS FOR H2 ELECTROLYSIS, COMPRESSION, WATER, STORAGE
C ***************************************************************************
C TGH2PYR  = TG-H2/YR PRODUCED FROM ELECTROLYSIS, COMPRESSED AND EITHER USED
C            IMMEDIATELY OR STORED
C TWHH2TOT = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C            THIS NUMBER ACCOUNTS FOR LEAKED HYDROGEN
C            THIS NUMBER IS AFTER T&D LOSSES, SO T&D LOSSES MUST BE ADDED TO THESE
C AVHRSPYR = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C H2ENERGY = TWH/TG-H2-PRODUCED-AND-COMPRESSED (=KWH/KG-H2)
C          = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C TLOADH2  = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE
C H2LDRES  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDCOM  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDIND  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDTRAN = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDAGR  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDOTH  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C HRSPYR   = AVERAGE NUMBER OF HOURS PER YEAR DURING WHOLE SIMULATION
C
      TGH2PYR   = TWHH2TOT / H2ENERGY
      TLOADH2   = TWHH2TOT / HRSPYR
      H2LDRES   = TWHH2RE  / HRSPYR
      H2LDCOM   = TWHH2CO  / HRSPYR
      H2LDIND   = TWHH2IN  / HRSPYR
      H2LDTRAN  = TWHH2TR  / HRSPYR
      H2LDAGR   = TWHH2AG  / HRSPYR
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      H2LDOTH   = TWHH2OT  / HRSPYR
C
C ***************************************************************************
C              MIN H2 ELECTROLYZER AND COMPRESSOR USE FACTOR
C ***************************************************************************
C EUSEFACMIN = MINIMUM FRACTION OF THE YEAR THAT ELECTROLYZER + COMPRESSOR
C              CAN BE USED. IF = 0.1 --> ELECTROLYER USED 10% OF HOURS OF
C              YEAR. SHORTER ACTUAL USE FACTOR -> LONGER LIFETIME, UP TO
C              LIMIT OF CALENDAR LIFE (ECALLIFE)
C              EUSEFACMIN USED TO LIMIT PEAK H2 PROD LOADS (H2PEAKLD)
C              ACTUAL USE FACTOR CALCULATED DURING PROGRAM.
C              FOR USA, EUSEFACMIN  DAYH2STOR  FACUTIL    FACON
C                          0.05         5        2.35       1.70
C                          0.10         7        2.35       1.70
C                          0.15         10       2.35       1.70
C                          0.20         14       2.35       1.70
C                          0.25         17       2.35       1.70
C                          0.30         19       2.35       1.70
C                          0.35         27       2.35       1.70
C                          0.40         38       2.35       1.70
C                          0.45         48       2.35       1.70
C
C                          0.05         10       2.35       1.70
C                          0.10         10       2.35       1.70
C                          0.15         10       2.35       1.70
C                          0.20         10       2.42       1.70
C                          0.25         10       2.51       1.70
C                          0.30         10       2.54       1.70
C                          0.35         10       2.543      1.70
C                          0.40         10       2.545      1.70
C                          0.45         10       2.546      1.70
C                          0.50         10       2.547      1.70
C                          0.60         10       2.55       1.70
C                          0.70         10       2.55       1.80
C                          0.60         10       2.55       1.93
C                          0.60         10       2.55       2.07
C                          0.60         10       2.55       2.07
C
C     EUSEFACMIN  = 0.05
C     EUSEFACMIN  = 0.1
      EUSEFACMIN  = 0.15
C     EUSEFACMIN  = 0.20
C     EUSEFACMIN  = 0.25
C     EUSEFACMIN  = 0.30
C     EUSEFACMIN  = 0.35
C     EUSEFACMIN  = 0.40
C     EUSEFACMIN  = 0.45
C     EUSEFACMIN  = 0.5
C     EUSEFACMIN  = 0.6
C     EUSEFACMIN  = 0.7
C     EUSEFACMIN  = 0.8
C     EUSEFACMIN  = 0.9
C     EUSEFACMIN  = 1.0
C
C ***************************************************************************
C                       MAXIMUM H2 STORAGE SIZE
C ***************************************************************************
C FRCH2STOR = MAX FRACTION OF TWH/YR OF H2 PRODUCED+CONSUMED THAT CAN BE STORED
C           = DAYH2STOR / DAYSPY = 0.27 (100/365) WHEN DAYH2STOR = 100.
C             COST OF STORING EVERY KG-H2 PRODUCED UP TO FRCH2STOR=1 ACCOUNTED FOR
C DAYH2STOR = NUMBER OF DAYS OF H2 STORAGE
C DAYSPY    = AVERAGE NUMBER OF DAYS PER YEAR DURING WHOLE SIMULATION
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C           = TOTAL TWH OF H2 THAT CAN BE PUT IN STORAGE. DAYH2STOR CHANGES VALUE.
C TWHH2TOT  = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C             THIS NUMBER ACCOUNTS FOR LEAKED HYDROGEN
C H2TANK    = MAX STORAGE (TG-H2) THAT H2 TANKS CAN HOLD AT GIVEN TIME
C H2ENERGY  = TWH/TG-H2-PRODUCED-AND-COMPRESSED (=KWH/KG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C
      FRCH2STOR = DAYH2STOR / DAYSPY
      H2STORMX  = TWHH2TOT * FRCH2STOR
      H2TANK    = H2STORMX / H2ENERGY
C
C H2PEAKLD = LARGEST INSTANT NON-GRID H2 PRODUCTION LOAD (TW) ALLOWED
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C            VIA ELECTROLYZERS/COMPRESSORS FOR NON-GRID H2 WHEN IMERGH2=0 OR
C            2 AND GRID PLUS NON-GRID H2 WHEN IMERGH2=1,3
C            ENSURE H2PEAKLD IS AT LEAST AS BIG AS FCCHARG WHEN IMERGH2=1,3
C TLOADH2  = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE=TWHH2TOT/HRSPYR
C IMERGH2  = 0: DO NOT INCLUDE ANY H2 FOR GRID ELECTRICITY
C          = 1: MERGE ELECTROLYZERS, COMPRESSORS, & STORAGE FOR
C               GRID AND NON-GRID H2.
C          = 2: KEEP ELECTROLYZERS, COMPRESSORS, & STORAGE
C              SEPARATE FOR GRID VERSUS NON-GRID H2
C          = 3: SAME AS IMERGH2=1, BUT BATDISCH=0
C FCCHARG  = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C STORHHFC = MAX HOURS H2 ELECTRICITY STORAGE AT MAX DISCHARGE RATE
C          = 0 WHEN IMERGH2 = 1 OR 0. APPLIES ONLY WHEN IMERGH2 = 2.
C
      H2PEAKLD  = TLOADH2 / EUSEFACMIN
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       STORHHFC = 0.
       H2PEAKLD = MAX(H2PEAKLD,FCCHARG)
      ELSEIF (IMERGH2.EQ.0) THEN
       FCCHARG  = 0.
       FCDISCH  = 0.
       STORHHFC = 0.
      ELSEIF (IMERGH2.EQ.2) THEN
       IF (STORHHFC.EQ.0.AND.FCDISCH.GT.0.) THEN
        WRITE(IOUT,*)'STORHHFC=0 WHEN IMERGH2=2, FCDISCH>0.SET STORHHFC'
        STOP
       ENDIF
      ENDIF
C
C H2SDISCH  = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             ASSUMES GRID H2 STORAGE ENERGY IS ENERGY USED TO
C             PRODUCE AND COMPRESS H2 = ENERGY EMBODIED IN H2 / H2CHAREFF
C           = FCDISCH (TW) / (H2DCEFF * H2CHAREFF)
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C             IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C             CELL EFFIC, ETC.
C           = H2DCEFF * H2CHAREFF
C H2DCEFF   = FRACTION OF ENERGY IN H2 STORAGE FOR ELECTRICITY
C             NOT LOST DUE TO LOSSES GOING THRU FUEL CELL & INVERTER
C             SUCH LOSSES INCLUDE FUEL CELL LOSS (0.65 EFF),
C           = 0.5362: LATENT HEAT LOSS (0.846 EFF) & DC TO AC INVERTER LOSSES (0.975 EFF)
C             JACOBSON 2023 H2-NH3-STEEL PAPER
C H2CHAREFF = FRACTION OF ENERGY IN H2FC STORAGE
C             NOT LOST DUE TO T&D LOSSES AND LOSSES CHARGING H2 STORAGE
C           = (1.-H2LOSRAT) * HIHEATH2 / H2ENERGY
C           = 0.8338: INCLUDES ELECTROLYZER LOSS (0.95 EFF), COMPRESSOR LOSS
C             (0.8803 EFF) AND LEAKS (0.997 EFF) - JACOBSON 2023 H2-NH3-STEEL PAPER
C HIHEATH2  = HIGHER HEATING VALUE OF H2 (39.39 KWH/KG-H2=141.8 MJ/KG-H2)
C
      H2SDISCH = FCDISCH / EFFH2CD
C
C ***************************************************************************
C          DETERMINE GMT TIME CORRESPONDING TO EACH LOADMATCH TIME STEP
C ***************************************************************************
C INITYLOAD = INITIAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED.
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2006 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IFINYLOAD = FINAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2007 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IBEGYLOAD = YEAR BETWEEN AND INCLUSIVE OF INITYLOAD AND IFINYLOAD
C             THAT LOAD DATA STARTS. SO, FOR EXAMPLE, IF
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C             SUPPOSE INITYLOAD = 2006 AND IFINYLOAD=2007 AND NYEARS=6
C             AND IBEGYLOAD = 2007, THEN LOAD DATA USED IN THE FOLLOWING ORDER:
C             2007 2006 2007 2006 2007 2006 .
C             SUPPOSE INITYLOAD = 2013 AND IFINYLOAD=2015 AND NYEARS=6
C             AND IBEGYLOAD=2013 THEN ORDER IS: 2013 2014 2015 2013 2014
C NHYEAR    = NUMBER OF HOURS PER YEAR OF SIMULATION (EITHER 8760 OR 8784)
```

```
C NHYCUM    = CUMULATIVE NUMBER OF HOURS OF SIMULATION PRIOR TO JAN 1 0 GMT
C             OF CURRENT I=1,NYEARS YEAR
C ILOAD     = COUNTS NUMBER OF HOURS OF LOAD DATA = 365x24=8760 OR 366x24=8784
C MXYLOAD   = MAX NUMBER OF YEARS OF LOAD DATA (11 = 2006 TO 2016) IN FILES
C LOADYR    = ACTUAL YEAR OF LOAD DATA (2006 TO 2016)
C IYLOAD    = 1..MXYLOAD YEAR OF LOAD DATA (MXYLOAD = 11: 2006 TO 2016)
C             FOR CURRENT I=1, NYEARS YEAR OF SIMULATION
C MXHPYEAR  = NUMBER OF HOURS PER YEAR FOR LEAP YEARS = 8784
C AHRSIM    = CURRENT GMT HOUR OF SIM CORRESPONDING TO LOAD DATA VALUE
C             (0.5 = 0-1 GMT JAN 1)
C NHRSIM    = TOTAL NUMBER OF HOURS OF MODEL SIMULATION HERE
C FHOURHR   = HIGH-RES TIME STEP (DTHRES) AS FRACTION OF AN HOUR
C
      LOADYR        = IBEGYLOAD - 1
      AHRSIM        = -0.5
      FHOURHR       = DTHRES / 3600.
      DTIME         = -1.1*FHOURHR
      J             = 0
C
      DO I          = 1, NYEARS
       LOADYR       = LOADYR + 1
C
       IF (LOADYR.GT.IFINYLOAD) THEN
        LOADYR      = INITYLOAD
       ENDIF
C
       IYLOAD       = LOADYR - IYBEFORE
C
       KHOUR        = 0
       DO M         = 1, MXHPYEAR
C
C SKIP LEAP DAY FOR NON LEAP YEARS
C HOURS 1417-1440 OF A YEAR CORRESPOND TO FEBRUARY 29 (LEAP DAY)`
C
C KDAY    = 1..NDAYYR DAY OF YEAR (1..365 NONLEAP YEARS, 1..366 LEAP YEARS)
C KHOUR   = 1..8760 HOURS OF YEAR FOR NON-LEAP YEARS; 1..8784 FOR LEAP YEARS
C MXHPDAY = NUMBER OF HOURS PER DAY (24)
C TIMLOAD = GMT HOUR OF SIMULATION (0. = 0-1 GMT JANUARY 1; 1.5 CORRESPONDS
C           TO 1-2 GMT JAN 1, 2.5 = 2-3 GMT JAN1 - CORRESPONDS TO
C           TIME OF LOAD DATA. J VARIES FROM 1..NHRSIM
C
        IF (NHYEAR(I).EQ.MXHPYEAR.OR.M.LT.1417.OR.M.GT.1440) THEN
         J          = J     + 1
         KHOUR      = KHOUR + 1
         KDAY       = 1 + (KHOUR-1)/MXHPDAY
         AHRSIM     = AHRSIM   + 1.
C
         IF (J.EQ.1) THEN
          TIMLOAD(J) = 0.
         ELSE
          TIMLOAD(J) = AHRSIM
         ENDIF
C
C DTHRES   = 30  = HIGH-RESOLUTION TIME STEP (S)
C FHOURHR  = HIGH-RES TIME STEP (DTHRES) AS FRACTION OF AN HOUR
C NTSPERHR = 120 = NUMBER OF 30-SECOND TIMES STEPS PER HR
C TLOADHR  = GMT HOUR OF SIM (-0.000833 = -15 TO +15 SEC JANUARY 1) CORRESPONDING TO
C            TIME OF HIGH-RESOLUTION LOAD DATA. VARIES FROM -0.000833...NHRSIM-0.0091667
C            0.0091667=1.1*FHOURHR
C
         LJ          = (J - 1) * NTSPERHR
         DO LH       = 1, NTSPERHR
          DTIME      = DTIME + FHOURHR
          LJ         = LJ + 1
          TLOADHR(LJ) = DTIME
         ENDDO
C
        ENDIF
C
       ENDDO
C      ENDDO M = 1, MXYPYEAR
C
      ENDDO
C     ENDDO I = 1, NYEARS
C
```

```
C ************************************************************************
C         READ TIME-DEPENDENT WIND, SOLAR SUPPLY DATA FROM GATOR-GCMOM
C ************************************************************************
C WTIME    = GMT DAYS PAST START OF SIMULATION, WHICH IS 12 GMT JAN 1, 2050
C DOMAIN   = EITHER COUNTRY NAME OR TOTAL DOMAIN
C CURLTWTB = CURRENT POWER GENERATION BY ONSHORE WIND TURBINES (TW) OVER
C            COUNTRY BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C            OF POWER FROM WIND BY EACH TURBINE.
C CUROTWTB = CURRENT POWER GENERATION BY OFFSHORE WIND TURBINES (TW) OVER
C            COUNTRY BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C            OF POWER FROM WIND BY EACH TURBINE.
C CURTWPVR = CURRENT ELEC GENERATED BY RES/COM/GOV ROOFTOP PV (TW)
C            (BEFORE T&D LOSSES) SUMMED OVER COUNTRY
C CURTWPVU = CURRENT ELEC GENERATED BY UTILITY PV (TW)
C            (BEFORE T&D LOSSES) SUMMED OVER COUNTRY
C CURTWCSP = CURRENT ELEC GENERATED BY SOLAR CSP (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CURTWSTH = CURRENT HEAT GENERATED BY SOLAR COLLECTORS (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CURTWHOT = CURRENT HEAT DEMAND (TW) FOR BUILDINGS IN COUNTRY
C CURTWCLD = CURRENT COLD DEMAND (TW) FOR BUILDINGS IN COUNTRY
C CUMLTWTB = CUMULATIVE POWER GEN BY ONSHORE WIND TURBINES (TW) OVER COUNTRY
C CUMOTWTB = CUMULATIVE POWER GEN BY OFFHORE WIND TURBINES (TW) OVER COUNTRY
C CUMTWRAV = CUM AVG ELEC GENERATED BY ROOFTOP PV (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWUAV = CUM AVG ELEC GENERATED BY UTILITY PV (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWCAV = CUM AVG ELEC GENERATED BY CSP (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWSAV = CUM AVG HEAT ENERATED BY SOLAR COLLECTORS (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWHOT = CURRENT HEAT DEMAND (TJ=TWxS) FOR BUILDINGS IN COUNTRY
C CUMTWCLD = CURRENT COLD DEMAND (TJ=TWxS) FOR BUILDINGS IN COUNTRY
C
      IFONE      = 0
      IWWS       = 0
      IFIRSTEP   = 1
      IENDSTEP   = 1
      IYRCOUNT   = 1
      ICUMDAYYR  = NDAYYR(IYRCOUNT)
C
      WTLAST     = -1.
      CURTWHOT   = 0.
      CURTWCLD   = 0.
C
 130  DO J          = 1, NUMGRIDS
       REGONWIND(J) = 0.
       REGOFWIND(J) = 0.
       REGROOFPV(J) = 0.
       REGUTILPV(J) = 0.
       REGCSP(   J) = 0.
       REGSTHERM(J) = 0.
       REGHEAT(  J) = 0.
       REGCOLD(  J) = 0.
      ENDDO
C
C READ TIME-DEPENDENT GATOR-GCMOM WIND, SOLAR DATA FROM wwssupworld
C
 131  IF (IFGATHEAT.GE.1) THEN
       READ(KWWS,132,END=150) WTIME, DOMAIN,
     1      CURLTWTB,CUROTWTB,CURTWPVR,CURTWPVU,CURTWCSP,CURTWSTH,
     1      CURTWHOT,CURTWCLD
      ELSE
       READ(KWWS,*,END=150) DUMMY, WTIME, DOMAIN,
     1      CURLTWTB,CUROTWTB,CURTWPVR,CURTWPVU,CURTWCSP,CURTWSTH
C      READ(KWWS,133,END=150) WTIME, DOMAIN,
C    1      CURLTWTB,CUROTWTB,CURTWPVR,CURTWPVU,CURTWCSP,CURTWSTH
      ENDIF
C
 132  FORMAT(6X,      0PF14.8,1X,A14,8(1PE15.8))
C133  FORMAT(6X,      0PF14.8,1X,A14,6(1PE15.8))
 134  FORMAT('WWST: ',0PF14.8,1X,A14,8(1PE15.8))
 136  FORMAT('WWST: ',0PF14.8,1X,A14,6(1PE15.8))
C
C ************************************************************************
```

```
C                       SET INDEX NUMBER FOR TIME STEPS
C ***************************************************************************
C IWWS     = COUNTS THE NUMBER OF TIME STEPS OF THE LOADMATCH SIMULATION
C IENDSTEP = 1: THIS ROW ENTRY IS THE LAST ENTRY OF A TIME STEP
C          = 0: THIS ROW ENTRY IS NOT THE LAST ENTRY OF A TIME STEP
C
      IF (IENDSTEP.EQ.1) THEN
       IWWS          = IWWS + 1
C
       IF (IWWS.GT.MXWWS) THEN
        WRITE(IOUT,*)'POWERWORLD: IWWS>MXWWS ',IWWS, MXWWS
        STOP
       ENDIF
C
C ***************************************************************************
C                       IDENTIFY CURRENT TIME
C ***************************************************************************
C IWWS     = COUNTS THE NUMBER OF TIME STEPS OF THE LOADMATCH SIMULATION
C TIMWWS   = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C WTIME    = GMT DAYS PAST START OF SIMULATION, WHICH IS 12 GMT JAN 1, 2050
C OFFSET   = TIME (HOURS) ADDED TO TIMWWS SO THAT IT IS CONSISTENT WITH TIMLOAD
C            SINCE SIMULATION FOR TIMWWS STARTED AT 12 GMT FIRST DAY, WHICH
C            ORIGINALLY CORRESPONDS TO TIMWWS=0. OFFSET MAKES THIS TIMWWS=0.5
C ISUPYEAR = 1: START SIM WITH FIRST YEAR OF MODEL OUTPUT WIND/SOLAR FIELDS
C          = 2: START SIM WITH SECOND YEAR OF MODEL OUTPUT WIND/SOLAR FIELDS
C TIMORIG  = ORIGINAL GMT DAYS PAST START OF SIMULATION FROM KWWS
C NDAYYR   = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C NHYEAR   = NUMBER OF HOURS PER YEAR OF SIMULATION (EITHER 8760 OR 8784)
C NHCUM    = CUMULATIVE NUMBER OF HOURS OF SIMULATION FROM START TO END
C            OF CURRENT YEAR I=1..NYEARS. THUS, NHCUM(1)=NHYEAR(1),
C            NHCUM(2)=NHYEAR(1) + NHYEAR(2), ETC.
C TIMLOAD  = GMT HOUR OF SIMULATION (0. = 0-1 GMT JANUARY 1; 1.5 CORRESPONDS
C            TO 1-2 GMT JAN 1, 2.5 = 2-3 GMT JAN1 - CORRESPONDS TO
C            TIME OF LOAD DATA. J VARIES FROM 1..NHRSIM
C IFONE    = 1: THEN THIS IS FIRST TIME>0 READ IN
C
C SET WTIME TO SMALL VALUE FIRST TIME STEP FOR HIGH-RESOLUTION DOMAINS
C TO ENSURE FIRST TIME STEP IS INCLUDED
C
       IF (WTIME.EQ.0.) WTIME = SMAL30
C
       TIMORIG(IWWS) = WTIME
       TIMWWS( IWWS) = WTIME * HRSPDAY + OFFSET
C
C ***************************************************************************
C                     DETERMINE YEAR OF TIME STEP IWWS
C ***************************************************************************
C IYRCOUNT  = CURRENT YEAR 1..MXYEAR OF SIMULATION
C ICUMDAYYR = CUMULATIVE NUMBER OF DAYS FROM BEGIN OF SIM TO END
C             OF CURRENT YEAR IYRCOUNT
C IYRWWS    = YEAR 1..MXYEAR CORRESPONDING TO EACH J=1..IWWS TIMESTEP
C
       IF (WTIME.GT.FLOAT(ICUMDAYYR)) THEN
        IYRCOUNT   = IYRCOUNT + 1
        ICUMDAYYR  = ICUMDAYYR + NDAYYR(IYRCOUNT)
       ENDIF

       IYRWWS(IWWS) = IYRCOUNT
C
       IF (ISUPYEAR.GE.2) THEN
        IF (TIMWWS(IWWS).LT.NHCUM(ISUPYEAR-1)) THEN
         TIMWWS( IWWS) = 0.
        ENDIF
       ENDIF
C
C HR1, HR2  = CURRENT & PREV TIME (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C
       IF (IFREWRITE.EQ.2) THEN
        IF (TIMWWS(IWWS).GT.0.AND.IFONE.NE.-1) THEN
         IFONE     = IFONE + 1
C
C FIRST STEP
         IF (IFONE.EQ.1) THEN
          HR1       = 0.
          HR2       = 0.
```

```
C
C MIDDLE STEPS
        ELSEIF (TIMWWS(IWWS).LT.TIMLOAD(NHRSIM)) THEN
         HR1       = TIMWWS(IWWS-1)
         HR2       = TIMWWS(IWWS)
C
C LAST STEP
        ELSE
         IFONE     = -1
         HR1       = TIMWWS(IWWS-1)
         HR2       = TIMWWS(IWWS)
        ENDIF
C        ENDIF IFONE
C
       ELSE
        HR1        = 0.
        HR2        = 0.
       ENDIF
C       ENDIF TIMWWS...
      ENDIF
C      ENDIF IFREWRITE
C
     ENDIF
C     ENDIF IENDSTEP=1
C
C ***************************************************************************
C        ELIMINATE REPEATED TIMES DUE TO GATOR-GCMOM CODE RESTARTS
C ***************************************************************************
C IFREWRITE = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                AND ELIMINATING AVERAGE VALUES (KEEPING INSTANT VALUES ONLY)
C                WHEN THIS IS COMPLETE, USE KWW2 FILE AS INPUT FOR IFREWRITE=2
C                APPLIES WHEN IFCONUS=0. WHEN IFCONUS=1, READ
C                wwssupconus.dat FROM PATHTEMP AND WRITE TO PATHHOME
C                AFTER FINISHINING IFREWRITE=1, CAN ERASE wwssupworld.dat
C IENDSTEP  = 1: THIS ROW ENTRY IS THE LAST ENTRY OF A TIME STEP
C           = 0: THIS ROW ENTRY IS NOT THE LAST ENTRY OF A TIME STEP
C
     IF (DOMAIN.EQ.'        DOMAIN'.OR.
    1   (IFREWRITE.EQ.3.AND.DOMAIN.EQ.GRIDUSE)) THEN
      IENDSTEP   = 1
     ELSE
      IENDSTEP   = 0
     ENDIF
C
     IF (IFREWRITE.EQ.1) THEN
      IF (WTIME.GT.WTLAST) THEN
C
       IF (IFGATHEAT.GE.1) THEN
        WRITE(KWW2,134) WTIME,DOMAIN,
    1       CURLTWTB,CUROTWTB,CURTWPVR,CURTWPVU,CURTWCSP,CURTWSTH,
    1       CURTWHOT,CURTWCLD
       ELSE
        WRITE(KWW2,136) WTIME,DOMAIN,
    1        CURLTWTB,CUROTWTB,CURTWPVR,CURTWPVU,CURTWCSP,CURTWSTH
       ENDIF
C
C UPDATE WTLAST WHEN REACH LAST ENTRY OF TIME STEP
C   OCCURS EACH TIME STEP WHEN IFCONUS=1; AT END OF ALL COUNTRIES WHEN IFCONUS=0
C
       IF (IENDSTEP.EQ.1) WTLAST = WTIME
C
      ENDIF
      GOTO 131
C
     ELSEIF (WTIME.LE.WTLAST) THEN
      WRITE(IOUT,*)'POWERWORLD:WTIME<=WTLAST. REMOVE REDUNDANT TIMES ',
    1              'IN KWWS ',WTIME,WTLAST
      STOP
     ENDIF
C
C ***************************************************************************
C   FOR 143-COUNTRIES, AGGEGATE WIND, SOLAR SUPPLY FROM GATOR-GCMOM OVER ALL
C                     COUNTRIES IN GRID REGION 'GRIDUSE'
C ***************************************************************************
```

```
C SUMONWIND = CURRENT TW ONSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             AS DETERMINED FROM GATOR-GCMOM SIMULATIONS, AT TIME WTIME
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C             WHEN IFCONUS=1, IT IS THE CONUS-AGGREGATE VALUE.
C SUMOFWIND = CURRENT TW OFFSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C SUMROOFPV = CURRENT TW ROOF PV WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C SUMUTILPV = CURRENT TW UTILITY PV, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C SUMCSP    = CURRENT TW CSP, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C SUMSTHERM = CURRENT TW SOLAR THERMAL, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C SUMHEAT   = CURRENT BUILDING END-USE HEAT LOAD (TW) FOR REGION FROM GATOR-GCMOM
C SUMCOLD   = CURRENT BUILDING END-USE COLD LOAD (TW) FOR REGION FROM GATOR-GCMOM
C
      IF (IFCONUS.EQ.1.OR.IFREWRITE.EQ.3) THEN
       WTLAST          = WTIME
       SUMONWIND(IWWS) = CURLTWTB
       SUMOFWIND(IWWS) = CUROTWTB
       SUMROOFPV(IWWS) = CURTWPVR
       SUMUTILPV(IWWS) = CURTWPVU
       SUMCSP(   IWWS) = CURTWCSP
       SUMSTHERM(IWWS) = CURTWSTH
       SUMHEAT(  IWWS) = CURTWHOT
       SUMCOLD(  IWWS) = CURTWCLD
C
      ELSE
C     ELSEIF CONUS=0 OR IFREWRITE=1 OR 2
C
C ***************************************************************************
C USE IFREWRITE=2 TO CREATE A SMALLER FILE WITH JUST INFORMATION SUMMED
C OVER GRID REGION TO AVOID NEEDING TO RE-READ DATA FOR ALL 143 COUNTRIES
C EACH TIME STEP OR TO SUM DATA OVER GRID REGION EACH TIME STEP.
C ***************************************************************************
C IFREWRITE = 1: REWRITE KWWS (wwssupworld.dat) FILE TO
C                KWW2 (wwssupreform.dat) ELIMINATING REDUNDANT TIMES
C                AND ELIMINATING AVERAGE VALUES (KEEPING INSTANT VALUES ONLY)
C                WHEN THIS IS COMPLETE, USE KWW2 FILE AS INPUT FOR IFREWRITE=2
C                APPLIES WHEN IFCONUS=0. WHEN IFCONUS=1, READ
C                wwssupconus.dat FROM PATHTEMP AND WRITE TO PATHHOME
C           = 2: APPLIES ONLY WHEN IFCONUS=0: READ KWW2 (wwssupreform.dat),
C                SUM VALUES EACH TIME STEP AMONG ALL COUNTRIES IN GRID
C                REGION GRIDUSE, REWRITE SUMMED VALUES TO A SMALLER FILE
C                KWW3 (wwssupworld.REGION) (FOR EACH REGION
C                ALSO CALCULATE CAPACITY FACTOR (CF) OF ONSHORE, OFFSHORE WIND;
C                ROOFTOP & UTILITY PV AND CSP FROM GATOR-GCMOM SIMULATIONS
C                BY COUNTRY.
C           = 3: APPLIES ONLY WHEN IFCONUS=0:
C                READ DATA FROM FILE wwssupworld.REGION RATHER THAN
C                wwssupworld.dat FOR ONE GRID REGION.
C                FILE KWW3 CONTAINS ONLY ONE LINE OF DATA FOR EACH TIME STEP,
C                WHICH ARE DATA SUMMED OVER ALL COUNTRIES IN GRID REGION GRIDUSE
C           = 0: READ AND PROCESS FILE KWWS
C                APPLIES WHEN IFCONUS=1 OR 0
C                (WHEN IFCONUS=0, READS ALL-COUNTRY DATA)
C
C ***************************************************************************
C           ENTER THIS IF AFTER REACHING LAST COUNTRY IN KWWS FILE
C ***************************************************************************
C DOMAIN = '        DOMAIN' IS AN ENTRY SUMMARIZING THE DATA FOR THE 143
C COUNTRIES SO IS NOT USED WHEN IFCONUS=0 SINCE THE CODE IS AGGREGATING
C OVER ALL COUNTRIES WITHIN GRID REGION IGRIDUSE. IF ALL 143 COUNTRIES ARE
C INCLUDED IN GRID REGION IGRIDUSE, THIS GIVES THE EXACT SAME RESULT
C AS READING IN THE VALUES FOR '        DOMAIN'
C ***************************************************************************
C
       IF (IENDSTEP.EQ.1) THEN
        WTLAST      = WTIME

C ***************************************************************************
C      ENSURE THAT ALL COUNTRIES IN EACH REGION FROM countrystats.dat ARE
```

```
C      ALSO TREATED IN wwssupworld FILE
C ***************************************************************************
C FOR EUROPE, KNT=NCOUNGRID-2 BECAUSE IN GATOR, KOSOVO+MONTENEGRO SUMMED INTO SERBIA
C FOR AFRICA AND AFRICA-EAST (WHEN AFRICA SPLIT INTO MULTIPLE REGIONS)
C           , KNT=NCOUNGRID-1 BECAUSE IN GATOR, NO DATA FOR SOUTH SUDAN SO AVERAGED IN
C             (PREV, NO DATA FOR NIGER IN GATOR-GCMOM BUT NOW IS)
C FOR SOUTH AMERICA, KNT=NCOUNGRID-1 BECAUSE NO DATA FOR SURINAME SO AVERAGED IN
C             (PREVIOUSLY, NO DATA FOR SURINAME IN GATOR-GCMOM, BUT NOW IS)
C
C WHEN A COUNTRY IN countrystats.dat IS NOT IN wwssupworld, THEN THE
C WIND, SOLAR POWER OUTPUTS FROM THAT COUNTRY ARE SCALED FROM THE
C COUNTRIES WITH DATA USING RATONSHW, RRATOFFSHW, RATROOFPV, ETC.
C AS SUCH, WINDS, SOLAR ASSUMED AVERAGE FOR THE GRID REGION
C ***************************************************************************
C IFIRSTEP = 1 DURING FIRST TIME STEP OF READING KWWS FILE
C ISUSED   = 1 IF COUNTRY DATA FOUND IN KWWS FILE
C          = 0 IF DATA NOT FOUND
C
C ENTER HERE IF IFREWRITE = 0 OR 2
C
        IF (IFIRSTEP.EQ.1) THEN
         IFIRSTEP = 0
C
         DO J       = 1, NUMGRIDS
          KOUNT     = 0
C
          DO I      = 1, NCOUNGRID(J)
           IC       = NUMCOUNGR(J,I)
           IF (ISUSED(IC).GT.0) KOUNT = KOUNT + 1
          ENDDO
C
          IF (
     1      (NAMEGRID(J).EQ.'EUROPE'.AND.KOUNT.NE.NCOUNGRID(J)-2).OR.
     1      (NAMEGRID(J).EQ.'AFRICA'.AND.KOUNT.NE.NCOUNGRID(J)-1).OR.
     1 (NAMEGRID(J).EQ.'AFRICA-EAST'.AND.KOUNT.NE.NCOUNGRID(J)-1).OR.
     1      (NAMEGRID(J).NE.'EUROPE'.AND.NAMEGRID(J).NE.'AFRICA'.AND.
     1       NAMEGRID(J).NE.'AFRICA-EAST'.
     1                               AND.KOUNT.NE.NCOUNGRID(J))) THEN
C
           WRITE(IOUT,*)'POWERWORLD: MISSING DATA FOR COUNTRY IN KWWS ',
     1                  KOUNT,NCOUNGRID(J),NAMEGRID(J)
C
           DO I      = 1, NCOUNGRID(J)
            IC       = NUMCOUNGR(J,I)
            WRITE(IOUT,*) I,NAMCOUNGR(J,I),ISUSED(IC)
           ENDDO
C          STOP
C
          ENDIF
         ENDDO
C
        ENDIF
C       ENDIF IFIRSTEP
C
C REWRITE DATA SUMMED OVER COUNTRIES IN EACH REGION FROM KWWS TO KWW3
C
        IF (IFREWRITE.EQ.2) THEN
         IF (IFGATHEAT.GE.1) THEN
          DO J      = 1, NUMGRIDS
           WRITE(KWW3+J-1,134) WTIME,NAMEGRID(J),
     1     REGONWIND(J),REGOFWIND(J),REGROOFPV(J),REGUTILPV(J),
     1     REGCSP(   J),REGSTHERM(J),REGHEAT(  J),REGCOLD(  J)
          ENDDO
         ELSE
          DO J      = 1, NUMGRIDS
           WRITE(KWW3+J-1,136) WTIME,NAMEGRID(J),
     1     REGONWIND(J),REGOFWIND(J),REGROOFPV(J),REGUTILPV(J),
     1     REGCSP(   J),REGSTHERM(J)
          ENDDO
         ENDIF
C
         GOTO 130
        ENDIF
C
C CONTINUE PROCESSING DATA FOR CURRENT TIME STEP ONCE COUNTRIES SUMMED
```

```
C PASS THROUGH HERE WHEN IFREWRITE = 0 ONLY
C
        SUMONWIND(IWWS) = REGONWIND(IGRIDUSE)
        SUMOFWIND(IWWS) = REGOFWIND(IGRIDUSE)
        SUMROOFPV(IWWS) = REGROOFPV(IGRIDUSE)
        SUMUTILPV(IWWS) = REGUTILPV(IGRIDUSE)
        SUMCSP(   IWWS) = REGCSP(   IGRIDUSE)
        SUMSTHERM(IWWS) = REGSTHERM(IGRIDUSE)
        SUMHEAT(  IWWS) = REGHEAT(  IGRIDUSE)
        SUMCOLD(  IWWS) = REGCOLD(  IGRIDUSE)
C
        GOTO 142
C
       ENDIF
C      ENDIF IENDSTEP=1
C
C ***************************************************************************
C           PASS THROUGH HERE WHEN IFREWRITE = 0 OR 2
C ***************************************************************************
C REGONWIND = CURRENT TW ONSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             AS DETERMINED FROM GATOR-GCMOM SIMULATIONS, AT TIME WTIME
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C REGOFWIND = CURRENT TW OFFSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C REGROOFPV = CURRENT TW ROOF PV WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C REGUTILPV = CURRENT TW UTILITY PV, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C REGCSP    = CURRENT TW CSP, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C REGSTHERM = CURRENT TW SOLAR THERMAL, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C REGHEAT   = CURRENT TW BUILDING HEAT LOAD, SUMMED OVER ALL COUNTRIES IN GRID REGION
C REGCOLD   = CURRENT TW BUILDING COLD LOAD, SUMMED OVER ALL COUNTRIES IN GRID REGION
C
       DO J            = 1, NUMGRIDS
        DO I           = 1, NCOUNGRID(J)
         IF (DOMAIN.EQ.NAMCOUNGR(J,I)) THEN
          IC           = NUMCOUNGR(J,I)
          ISUSED(IC)   = 1
          REGONWIND(J) = REGONWIND(J) + CURLTWTB
          REGOFWIND(J) = REGOFWIND(J) + CUROTWTB
          REGROOFPV(J) = REGROOFPV(J) + CURTWPVR
          REGUTILPV(J) = REGUTILPV(J) + CURTWPVU
          REGCSP(   J) = REGCSP(   J) + CURTWCSP
          REGSTHERM(J) = REGSTHERM(J) + CURTWSTH
          REGHEAT(  J) = REGHEAT(  J) + CURTWHOT
          REGCOLD(  J) = REGCOLD(  J) + CURTWCLD
         ENDIF
        ENDDO
       ENDDO
C
C ***************************************************************************
C  READ WIND/SOLAR DELIVERED POWER BY COUNTRY FROM 3-D GATOR-GCMOM FOR
C  CALCULATING CAPACITY FACTOR WITH, THEN STOP. THESE CFS CAN BE USED IN
C  SPREADSHEET TO RE-ESTIMATE NUMBERS OF WIND/SOLAR DEVICES NEEDED IN COUNTRY
C ***************************************************************************
C NCOUNTRY   = NUMBER OF COUNTRIES WHEN IFCONUS=0
C NAMECOUN   = NAME OF EACH 1..NCOUNTRY COUNTRY
C POWCOUNTRY = CURRENT POWER GENERATION BY ENERGY DEVICE (TW) IN
C              COUNTRY IC BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C              OF POWER FROM WIND BY TURBINES.
C ENCOUNTRY  = CUMULATIVE ENERGY PRODUCTION (TWH) OVER SIMULATION FROM
C              ENERGY DEVICE IN COUNTRY IC BEFORE T&D LOSSES BUT ACCOUNTING
C              FOR EXTRACTION OF POWER FROM WIND BY TURBINES
C HR1, HR2   = CURRENT TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C
       IF (IFREWRITE.EQ.2.AND.(HR1.NE.0.OR.HR2.NE.0.)) THEN
        DO IC          = 1, NCOUNTRY
         IF (DOMAIN.EQ.NAMECOUN(IC)) THEN
          HRDIF        = HR2 - HR1
C
C CALCULATE ENCOUNTRY WITH VALUES FROM PREVIOUS AND CURRENT TIME STEP
```

```
C
          ENCOUNTRY(IC,IONWIND)  = ENCOUNTRY( IC,IONWIND)
     1       + 0.5 * (POWCOUNTRY(IC,IONWIND)  + CURLTWTB) * HRDIF
          ENCOUNTRY(IC,IOFFWIND) = ENCOUNTRY( IC,IOFFWIND)
     1       + 0.5 * (POWCOUNTRY(IC,IOFFWIND) + CUROTWTB) * HRDIF
          ENCOUNTRY(IC,IRESPV)   = ENCOUNTRY( IC,IRESPV)
     1       + 0.5 * (POWCOUNTRY(IC,IRESPV)   + CURTWPVR) * HRDIF
          ENCOUNTRY(IC,IUTILPV)  = ENCOUNTRY( IC,IUTILPV)
     1       + 0.5 * (POWCOUNTRY(IC,IUTILPV)  + CURTWPVU) * HRDIF
          ENCOUNTRY(IC,ICSPSTOR) = ENCOUNTRY( IC,ICSPSTOR)
     1       + 0.5 * (POWCOUNTRY(IC,ICSPSTOR) + CURTWCSP) * HRDIF
          ENCOUNTRY(IC,ISOLTHM)  = ENCOUNTRY( IC,ISOLTHM)
     1       + 0.5 * (POWCOUNTRY(IC,ISOLTHM)  + CURTWSTH) * HRDIF
C
C UPDATE POWCOUNTRY (TW) WITH NEW VALUES FROM CURRENT TIME STEP
C
          POWCOUNTRY(IC,IONWIND)  = CURLTWTB
          POWCOUNTRY(IC,IOFFWIND) = CUROTWTB
          POWCOUNTRY(IC,IRESPV)   = CURTWPVR
          POWCOUNTRY(IC,IUTILPV)  = CURTWPVU
          POWCOUNTRY(IC,ICSPSTOR) = CURTWCSP
          POWCOUNTRY(IC,ISOLTHM)  = CURTWSTH
         ENDIF
C        ENDIF DOMAIN=NAMECOUN
C
        ENDDO
C       ENDDO IC = 1, NCOUNTRY
C
       ENDIF
C      ENDIF IFREWRITE=2.AND.(HR1.NE.0.OR.HR2.NE.0.))
C
C READ ANOTHER COUNTRY FOR CURRENT TIME STEP
C
       GOTO 131
C
 142   CONTINUE
C      CONTINUE TO PROCESS SUPPLIES FOR ONE TIME STEP
C
      ENDIF
C     ENDIF IFCONUS=0
C
C PROCESS ANOTHER TIME STEP OF WIND, SOLAR DATA
C
      GOTO 130
C
C FINISH READING KWWS
C
 150  CLOSE(KWWS)
C
      IF (IFREWRITE.EQ.1) THEN
       CLOSE(KWW2)
       STOP
      ELSEIF (IFREWRITE.EQ.2) THEN
       DO J = 1, NUMGRIDS
        CLOSE(KWW3+J-1)
       ENDDO
      ENDIF
C     ENDIF IFREWRITE
C
C ***************************************************************************
C                           DETERMINE TIME STEPS
C ***************************************************************************
C IWWS    = NUMBER OF TIME STEPS OF THE LOADMATCH SIMULATION
C TIMWWS  = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C PERHRS  = TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C IFONE   = 1: THEN THIS IS FIRST TIME>0 READ IN
C TIMLOAD = GMT HOUR OF SIMULATION (0.5 = 0-1 GMT JANUARY 1) CORRESPONDING TO
C           TIME OF LOAD DATA. VARIES FROM 0.5..NHRSIM-0.5
C HEATMIN = MIN TW OF HEAT EACH TIME STEP TO ENSURE SOME WATER HEAT
C COLDMIN = MIN TW OF COLD EACH TIME STEP TO ENSURE SOME REFRIGERATION
C HEATADD = SUM OF SUMHEAT (TWH) OVER ALL IWWS TIME STEPS
C COLDADD = SUM OF SUMCOLD (TWH) OVER ALL IWWS TIME STEPS
C SHMAX   = MAX VALUE OF SUMHEAT(TW)
C
      IFONE       = 0
```

```
      AIFCOLD     = 0.
      AIFWARM     = 0.
      ADDHOURS    = 0.
      HEATADD     = 0.
      COLDADD     = 0.
      SHMAX       = 0.
C
      DO J        = 1, IWWS
       IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
        IFONE     = IFONE + 1
        IYY       = IYRWWS(J)
        IF (IFONE.EQ.1) THEN
         PERHRS(J) = 0.5 * (TIMWWS(J+1) - TIMWWS(J))
        ELSEIF (J.EQ.IWWS) THEN
         PERHRS(J) = 0.5 * (TIMWWS(J)   - TIMWWS(J-1))
        ELSE
         PERHRS(J) = 0.5 * (TIMWWS(J+1) - TIMWWS(J-1))
        ENDIF
C
        HRSINYR( IYY) = HRSINYR(IYY) + PERHRS(J)
        ADDHOURS      = ADDHOURS     + PERHRS(J)
C
        HEATADD    = HEATADD + SUMHEAT(J) * PERHRS(J)
        COLDADD    = COLDADD + SUMCOLD(J) * PERHRS(J)
        SHMAX      = MAX(SHMAX,SUMHEAT(J))
C
        IF (SUMHEAT(J).GT.0.) AIFWARM = AIFWARM + 1.
        IF (SUMCOLD(J).GT.0.) AIFCOLD = AIFCOLD + 1.
C
        IF (PERHRS(J).LE.0.) THEN
         WRITE(IOUT,*)'POWERWORLD1: TIMWWS(J+1)<TIMWWS(J) IN ',
     1               'KWWS. REMOVE EXCESS TIMES ',
     1                TIMORIG(J+1),TIMORIG(J),J,TIMWWS(J+1),TIMWWS(J)
         STOP
        ENDIF
C
       ENDIF
C      ENDIF TIMWWS>0
      ENDDO
C     ENDDO J = 1, IWWS
C
C SUMHEAT  = CURRENT BUILDING END-USE HEAT LOAD (TW) FOR REGION FROM GATOR-GCMOM
C SUMCOLD  = CURRENT BUILDING END-USE COLD LOAD (TW) FOR REGION FROM GATOR-GCMOM
C CURHEAT  = CURRENT BUILDING END-USE HEAT LOAD (TW) FOR REGION FROM GATOR-GCMOM
C CURCOLD  = CURRENT BUILDING END-USE COLD LOAD (TW) FOR REGION FROM GATOR-GCMOM
C AVHEATLD = INITIALLY TWH-HEAT LOAD FOR BUILDINGS OVER ENTIRE KWWS DATASET
C AVCOLDLD = INITIALLY TWH-COLD LOAD FOR BUILDINGS OVER ENTIRE KWWS DATASET
C ADDHOURS = HOURS OF DATA OVER ENTIRE KWWS DATASET
C HRSINYR  = HOURS OF DATA DURING EACHYEAR IYY
C HEATMIN  = MIN TW OF HEAT EACH TIME STEP TO ENSURE SOME WATER HEAT
C COLDMIN  = MIN TW OF COLD EACH TIME STEP TO ENSURE SOME REFRIGERATION
C FRCOLD   = FRACTION OF TIME STEPS WHERE SUMCOLD > 0
C FRWARM   = FRACTION OF TIME STEPS WHERE SUMWARM > 0
C COLDFAC  = FACTOR TO DECREASE COLDMIN BY WHEN FEW HOURS OF COOLING DURING YEAR
C            OTHERWISE COOLING SPIKE DURING A FEW HOURS OF YEAR
C WARMFAC  = FACTOR TO DECREASE HEATMIN BY WHEN FEW HOURS OF HEATING DURING YEAR
C            OTHERWISE WARMING SPIKE DURING A FEW HOURS OF YEAR
C HEATADD  = SUM OF SUMHEAT (TWH) OVER ALL IWWS TIME STEPS
C COLDADD  = SUM OF SUMCOLD (TWH) OVER ALL IWWS TIME STEPS
C
      IF (IFGATHEAT.EQ.1) THEN
       FRCOLD      = AIFCOLD / IFONE
       FRWARM      = AIFWARM / IFONE
C
       IF (FRCOLD.GT.0.3) THEN
        COLDFAC = 30.
       ELSEIF (FRCOLD.GT.0.1) THEN
        COLDFAC = 10.
       ELSEIF (FRCOLD.GT.0.04) THEN
        COLDFAC = 1.
       ELSE
        COLDFAC = 0.01
       ENDIF
C
       IF (FRWARM.GT.0.3) THEN
```

```
        WARMFAC = 30.
       ELSEIF (FRWARM.GT.0.1) THEN
        WARMFAC = 10.
       ELSEIF (FRWARM.GT.0.04) THEN
        WARMFAC = 1.
       ELSE
        WARMFAC = 0.01
       ENDIF
C
       HEATAVG     = HEATADD / ADDHOURS
       COLDAVG     = COLDADD / ADDHOURS
C
       HEATMIN     = HEATAVG / WARMFAC
       COLDMIN     = COLDAVG / COLDFAC
C
C THIS CAPTURES CASES THAT HAVE A LOT OF HEATING DAYS (LOTS OF
C VALUES OF FRWARM BUT FEW HOURS WHERE THE HEATING IS MORE THAN
C A SMALL AMOUNT (E.G., AS IN THE PHILIPPINES)
C SHMAX/HEATMIN = RATIO OF SIMULATION MAX TO DAILY AVG MIN HEATING
C
       IF (SHMAX/HEATMIN.GT.300.) THEN
        HEATMAX     = HEATMIN * 20.
       ELSE
        HEATMAX     = HEATMIN * 300.
       ENDIF
C
       DO J        = 1, IWWS
        IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
         IYY          = IYRWWS(J)
         CURHEAT( J)   = MIN(MAX(SUMHEAT(  J),HEATMIN),HEATMAX)
         CURCOLD( J)   =     MAX(SUMCOLD(  J),COLDMIN)
         AVHEATLD(IYY) = AVHEATLD(IYY) + CURHEAT( J) * PERHRS(J)
         AVCOLDLD(IYY) = AVCOLDLD(IYY) + CURCOLD( J) * PERHRS(J)
        ENDIF
C       ENDIF TIMWWS>0
       ENDDO
C      ENDDO J = 1, IWWS
C
      ENDIF
C     ENDIF IFGATHEAT=1
C
C AVHEATLD = ANNUAL AVG BUILDING HEAT LOAD (TW) OVER ENTIRE KWWS DATASET
C            FROM GATOR-GCMOM. MAKE SURE NOT=0 SINCE COLD LOAD CALCULATED FROM THIS.
C AVCOLDLD = ANNUAL AVG BUILDING COLD LOAD (TW) OVER ENTIRE KWWS DATASET
C            FROM GATOR-GCMOM. MAKE SURE NOT=0 SINCE HEAT LOAD CALCULATED FROM THIS.
C
      IF (IFGATHEAT.EQ.1) THEN
       DO I         = 1, NYEARS
        AVHEATLD(I) = AVHEATLD(I) / HRSINYR(I)
        AVCOLDLD(I) = AVCOLDLD(I) / HRSINYR(I)
       ENDDO
      ENDIF
C
C ***************************************************************************
C       ESTIMATE FRACTION OF TOTAL AIR HEATING+COOLING THAT IS COOLING
C ***************************************************************************
C ACFRACTOT = EST FRACTION OF TOTAL AIR HEATING + COOLING ENERGY THAT IS COOLING
C             ENERGY. DO NOT INCLUDE WATER HEATING OR REFRIGERATION SINCE THOSE
C             TEMPERATURES MUST BE RAISED/LOWERED MUCH MORE THAN FOR AIR COMFORT
C AVGHDD    = ANNUAL-AVG HEATING DEGREE DAYS PER YEAR (F) IN GRID J=1,NUMGRIDS
C AVGCDD    = ANNUAL-AVG COOLING DEGREE DAYS PER YEAR (F) IN GRID J=1,NUMGRIDS
C CDDHDD    = COOLING DEGREE DAYS DIVIED BY HEATING DEGREE DAYS. MULTIPLY
C             FRACTION OF LOAD THAT IS AIR HEATING BY CDDHDD TO OBTAIN
C             FRACTION OF LOAD THAT IS AIR CONDITIONING.
C TOTCOLD   = ANNUAL-AVG BUILDING TOT COLD LOAD AMONG ALL SECTORS (TW)
C TOTHOT    = ANNUAL-AVG BUILDING TOT HEAT LOAD AMONG ALL SECTORS (TW)
C AVHEATLD  = ANN AVG BUILDING HEAT LOAD (TW) OVER KWWS DATASET FROM GATOR-GCMOM
C AVCOLDLD  = ANN AVG BUILDING COLD LOAD (TW) OVER KWWS DATASET FROM GATOR-GCMOM
C
C
C IF READING BUIDING HEAT AND COLD ENERGY FOR EACH COUNTRY FROM GATOR-GCMOM
C
      IF (IFGATHEAT.EQ.1) THEN
       ACFRACTOT = AVCOLDLD(1) / (AVCOLDLD(1) + AVHEATLD(1))
C
```

```
       IF (AVHEATLD(1).GT.0.) THEN
        CDDHDD   = MIN(AVCOLDLD(1) / AVHEATLD(1),10000.)
       ELSE
        CDDHDD   = 10.
       ENDIF
C
C IF USING HEATING AND COOLING DEGREE DATA FOR EACH COUNTRY
C
      ELSE
       ACFRACTOT = AVGCDD(IGRIDUSE)/(AVGCDD(IGRIDUSE)+AVGHDD(IGRIDUSE))
C
       IF (AVGHDD(IGRIDUSE).GT.0.) THEN
        CDDHDD   = MIN(AVGCDD(IGRIDUSE) / AVGHDD(IGRIDUSE),10000.)
       ELSE
        CDDHDD   = 10.
       ENDIF
      ENDIF
C     ENDIF IFGATHEAT=1
C
C ***************************************************************************
C FRACTIONS OF HEAT AND COLD LOAD THAT ARE FLEXIBLE (SUBJECT TO DEMAND
C RESPONSE) IF CAN'T BE SUPPLIED IN CURRENT TIME STEP BY HEAT OR COLD
C STORAGE, RESPECTIVELY. IF LOAD IS FLEXIBLE, THEN CAN BE PUSHED FORWARD
C MXDEMRHR HOURS
C ***************************************************************************
C FHEATFLX = FRACTION OF HEAT LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY HEAT STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C FCOLDFLX = FRACTION OF COLD LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY COLD STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C
      FHEATFLX = 0.15
      FCOLDFLX = 0.15
C
      COLDINFX = 0.
      HOTINFLX = 0.
      COLDFLEX = 0.
      HOTFLEX  = 0.
C
C ***************************************************************************
C        FIND FRACTION OF RESIDENTIAL LOAD THAT CAN BE STORED IN TES
C ***************************************************************************
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C FMAXAC    = MAXIMUM FRACTION OF ELECTRICITY USE THAT IS USED FOR AIR
C             CONDITIONING+REFRIGERATION
C
C     FMAXAC     = 0.4
      FMAXAC     = 0.8
C
C FRCRESAC  = FRACTION OF RESIDENTIAL LOAD THAT IS AC FROM US GRID PAPER
C FRCRESWH  = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS WATER HEATING
C FRCRESAH  = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS AIR HEATING
C
      FRCRESAC   = 0.062
      FRCRESAH   = 0.415
      FRCRESWH   = 0.177
C
C PARTITION TOTAL WATER+AIR HEATING ENERGY BETWEEN WATER AND AIR HEATING
C
      IF (IFCONUS.EQ.0) THEN
C
C FRCLOWHT  = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C             THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C FRCHTWAT  = FRAC OF TOTAL HEAT USED IN BUILDINGS THAT IS USED FOR WATER
C             HEATING. THE REST IS USED FOR AIR HEATING/STOVES
C FELECREG  = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C             IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C
       FRCLOWHT  = 1. - FELECREG(IGRIDUSE,IRESID)
       FRCHTWAT  = FRCRESWH / (FRCRESWH + FRCRESAH)
C
C FRCRESWH  = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS WATER HEATING
C FRCRESAH  = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS AIR HEATING
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C
       FRCRESWH  = FRCLOWHT * FRCHTWAT
       FRCRESAH  = FRCLOWHT - FRCRESWH
C
C PARTITION NON-HEATING ENERGY = ELECTRICITY AMONG AC AND OTHER ELECTRICITY
C           LIMIT AIR CONDITIONING TO A FRACTION OF TOTAL ELECTRICITY USE
C
C CDDHDD    = COOLING DEGREE DAYS DIVIDED BY HEATING DEGREE DAYS. MULTIPLY
C             FRACTION OF LOAD THAT IS AIR HEATING BY CDDHDD TO OBTAIN
C             FRACTION OF LOAD THAT IS AIR CONDITIONING.
C FMAXAC    = MAXIMUM FRACTION OF ELECTRICITY USE THAT IS USED FOR AIR
C             CONDITIONING+REFRIGERATION
C
       FRCRESAC  = MIN(FRCRESAH*CDDHDD,FELECREG(IGRIDUSE,IRESID)*FMAXAC)
      ELSE
       FRCLOWHT  = FRCRESWH + FRCRESAH
      ENDIF
C     ENDIF IFCONUS=0
C
C FRCRESOT  = FRACTION OF RESIDENTIAL LOAD THAT IS OTHER (NOT AIR/WAT HEAT/COOL)
C
      FRCRESOT   = 1. - FRCRESAC - FRCRESAH - FRCRESWH
C
C FRCFLXRAC  = FRACTION OF RESIDENTIAL AC LOAD THAT IS FLEXIBLE (OBTAINED
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              FROM FILE EndUseforStorage.xlsx
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C              IN BAU CASE, COLD LOAD IS SATISFIED BY ELECTRICITY
C              RUNNING AIR CONDITIONING, WHICH IS A HEAT PUMP THAT COOLS
C              ONLY. SO THE USE OF HEAT PUMPS HERE DOES NOT CHANGE COLD LOAD.
C FRCFLXRAH  = FRACTION OF RESIDENTIAL AIR HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C FRCFLXRWH  = FRACTION OF RESIDENTIAL WATER HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C              SINCE ALL WATER IN BUILDINGS IS EITHER STORED IN WATER
C              TANK OR DISTRICT HEAT STORAGE, ALMOST ALL WATER HEATING FLEXIBLE
C FRCFLXROT  = FRACTION OF RESIDENTIAL OTHER LOAD THAT IS FLEXIBLE
C              (SUBJECT TO DEMAND-RESPONSE)
C FDISTHEAT  = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C              USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C              DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C              THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C              HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C              WITHIN BUILDINGS WITH HEAT PUMPS.
C
      FRCFLXRAC  = FDISTHEAT
      FRCFLXRAH  = FDISTHEAT
      FRCFLXRWH  = 0.95
      FRCFLXROT  = 0.15
C
C BLOADRES  = 2050 RESIDENTIAL WWS LOAD (TW) AFTER HEAT PUMPS
C FLXLDRAC  = RES AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDRAH  = RES AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDRWH  = RES WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDROT  = RES OTHER LOAD (TW) THAT IS FLEXIBLE (SUBJECT TO DRM OR
C             FOR PRODUCING H2)
C
      FLXLDRAC   = BLOADRES * FRCRESAC * FRCFLXRAC
      FLXLDRAH   = BLOADRES * FRCRESAH * FRCFLXRAH
      FLXLDRWH   = BLOADRES * FRCRESWH * FRCFLXRWH
      FLXLDROT   = BLOADRES * FRCRESOT * FRCFLXROT
C
C ***************************************************************************
C      REDUCE RESIDENTIAL LOAD DUE TO SUPPLYING HEAT/COLD WITH HEAT PUMPS
C ***************************************************************************
C ADDCOLD  = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) IN CURRENT SECTOR
C ADDHOT   = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) IN CURRENT SECTOR
C COLDINFX = ANNUAL AVG TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = ANNUAL AVG TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C FRCRESAC = FRACTION OF RESIDENTIAL LOAD THAT IS AC
C FRCRESWH = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS WATER HEATING
C FRCRESAH = FRACTION OF TOTAL RESIDENTIAL LOAD THAT IS AIR HEATING
C COLDFLEX = PORTION OF COLD LOAD (TW) NOT MET BY STORAGE THAT CAN
```

```
C            BE MET BY DEMAND RESPONSE.
C HOTFLEX  = PORTION OF WARM LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C
      ADDCOLD    = BLOADRES * FRCRESAC * (1. - FRCFLXRAC)
      ADDHOT     = BLOADRES * FRCRESAH * (1. - FRCFLXRAH)
     1           + BLOADRES * FRCRESWH * (1. - FRCFLXRWH)
C
C COLDINFX AND HOTINFLX COULD BE MULTIPLIED BY FRCFLXROT TO GIVE THE
C COLD AND HOT LOAD NOT SUBJECT TO STORAGE THAT IS SUBJECT TO DEMAND
C RESPONSE. OTHERWISE, COLD & HOT LOADS NOT SUBJECT TO STORAGE ARE
C NOT SUBJECT TO DEMAND RESPONSE. THE RESULT WOULD BE ADDED TO TLOADDRM
C
      COLDINFX   = COLDINFX + ADDCOLD * (1. - FRCFLXROT)
      HOTINFLX   = HOTINFLX + ADDHOT  * (1. - FRCFLXROT)
      COLDFLEX   = COLDFLEX + ADDCOLD * FRCFLXROT
      HOTFLEX    = HOTFLEX  + ADDHOT  * FRCFLXROT
C
C TFLEXRES   = TOTAL RESIDENTIAL FLEXIBLE LOAD (TW) SUBJECT TO STORAGE
C FLXLDROT   = RES OTHER LOAD (TW) THAT IS FLEXIBLE (SUBJECT TO DRM OR
C              FOR PRODUCING H2)
C FRCFLEXRES = FRACTION OF RESIDENTIAL LOAD THAT IS FLEXIBLE
C FLXRNOH2   = ANNUAL AVG FLEX RESIDENTIAL LOAD (TW) NOT FOR PRODUCING  H2
C H2LDRES    = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C FLXELRES   = RESIDENTIAL LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C              USED FOR PRODUCING H2
C
      TFLEXRES   = FLXLDRAC + FLXLDRAH + FLXLDRWH + FLXLDROT
      FRCFLEXRES = TFLEXRES / BLOADRES
      FLXRNOH2   = TFLEXRES - H2LDRES
      FLXELRES   = FLXLDROT - H2LDRES
C
      WRITE(IOUT,137) FRCLOWHT, FRCRESAH, FRCRESWH, FRCRESAC, FRCRESOT,
     1                FRCFLXRAH,FRCFLXRWH,FRCFLXRAC,FRCFLXROT,
     1                FLXLDRAH, FLXLDRWH, FLXLDRAC, FLXELRES,
     1                H2LDRES,  TFLEXRES, BLOADRES, FRCFLEXRES
C
 137  FORMAT('********** RESIDENTIAL SECTOR **********'/,
     1      'FRCLOWHT   FRCRESAH    FRCRESWH   FRCRESAC  FRCRESOT'/,
     1       5(0PF11.4)//,
     1      'FRCFLXRAH  FRCFLXRWH  FRCFLXRAC  FRCFLXROT  '/,
     1      4(0PF11.4)//,
     1      'FLXLDRAHTW FLXLDRWH   FLXLDRAC   FLXELRES   ',
     1      'H2LDRES    TFLEXRES   BLOADRES   FRCFLEXRES'/,8(1PE11.4)//)
C
C ***************************************************************************
C FRAC OF COMMERCIAL & PUBLIC SERVICE (GOVERNMENT) LOAD THAT CAN BE STORED IN TES
C ***************************************************************************
C COMMERCIAL AND PUBLIC SERVICE
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C FRCCOMWH  = FRACTION OF COMMERCIAL LOAD THAT IS WATER HEATING
C FRCCOMAH  = FRACTION OF COMMERCIAL LOAD THAT IS AIR HEATING
C
      FRCCOMAH  = 0.3626
      FRCCOMWH  = 0.0768
C
C RFTOAC   = RATIO OF FRACTION REFRIG TO AIR CONDITIONING LOADS IN COMMERCIAL SECT
C FRCCOMAC = FRACTION OF COMMERCIAL LOAD THAT IS AC
C FRCCOMRF = FRACTION OF COMMERCIAL LOAD THAT IS REFRIGERATION
C
      FRCCOMAC  = 0.0791
      FRCCOMRF  = 0.0584
      RFTOAC    = FRCCOMRF / FRCCOMAC
C
C PARTITION TOTAL WATER+AIR HEATING ENERGY BETWEEN WATER AND AIR HEATING
C
C FRCLOWHT  = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C             THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C FRCHTWAT  = FRAC OF TOTAL HEAT USED IN BUILDINGS THAT IS USED FOR WATER
C             HEATING. THE REST IS USED FOR AIR HEATING/STOVES
C
      IF (IFCONUS.EQ.0) THEN
       FRCLOWHT = 1. - FELECREG(IGRIDUSE,ICOMM)
       FRCHTWAT = FRCCOMWH / (FRCCOMWH + FRCCOMAH)
```

```
C
C FRCCOMWH  = FRACTION OF COMMERCIAL LOAD THAT IS WATER HEATING
C FRCCOMAH  = FRACTION OF COMMERCIAL LOAD THAT IS AIR HEATING
C
       FRCCOMWH = FRCLOWHT * FRCHTWAT
       FRCCOMAH = FRCLOWHT - FRCCOMWH
C
C PARTITION NON-HEATING ENERGY = ELECTRICITY AMONG AC, REFRIGERATION, AND OTHER
C           LIMIT AIR CONDITIONING TO A FRACTION OF TOTAL ELECTRICITY USE
C
C CDDHDD    = COOLING DEGREE DAYS DIVIED BY HEATING DEGREE DAYS. MULTIPLY
C             FRACTION OF LOAD THAT IS AIR HEATING BY CDDHDD TO OBTAIN
C             FRACTION OF LOAD THAT IS AIR CONDITIONING.
C FMAXAC    = MAXIMUM FRACTION OF ELECTRICITY USE THAT IS USED FOR AIR
C             CONDITIONING+REFRIGERATION
C
       FRCCOMAC  = MIN(FRCCOMAH*CDDHDD,FELECREG(IGRIDUSE,ICOMM)*FMAXAC)
       FRCCOMRF  = RFTOAC * FRCCOMAC
      ELSE
       FRCLOWHT  = FRCCOMWH + FRCCOMAH
      ENDIF
C
C FRCCOMOT  = FRACTION OF COMMERCIAL LOAD THAT IS OTHER
C
      FRCCOMOT  = 1. - FRCCOMAC - FRCCOMRF - FRCCOMAH - FRCCOMWH
C
C FRCFLXCAC  = FRACTION OF COMMERCIAL AC LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXCRF  = FRACTION OF COMMERCIAL REFRIGERATION LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXCAH  = FRACTION OF COMMERCIAL AIR HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C FRCFLXCWH  = FRACTION OF COMMERCIAL WATER HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C              SINCE ALL WATER IN BUILDINGS IS EITHER STORED IN WATER
C              TANK OR DISTRICT HEAT STORAGE, ALMOST ALL WATER HEATING FLEXIBLE
C FRCFLXCOT  = FRACTION OF COMMERCIAL OTHER LOAD THAT IS FLEXIBLE
C              (SUBJECT TO DEMAND-RESPONSE)
C FDISTHEAT  = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C              USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C              DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C              THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C              HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C              WITHIN BUILDINGS WITH HEAT PUMPS.
C
      FRCFLXCAC = FDISTHEAT
      FRCFLXCRF = FDISTHEAT
      FRCFLXCAH = FDISTHEAT
      FRCFLXCWH = 0.95
      FRCFLXCOT = 0.15
C
C BLOADCOM  = 2050 COMMERCIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C FLXLDCAC  = COM AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCRF  = COM REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCAH  = COM AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCWH  = COM WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCOT  = COM OTHER LOAD (TW) THAT IS FLEXIBLE (SUBJECT TO DRM OR
C             FOR PRODUCING H2)
C
      FLXLDCAC   = BLOADCOM * FRCCOMAC * FRCFLXCAC
      FLXLDCRF   = BLOADCOM * FRCCOMRF * FRCFLXCRF
      FLXLDCAH   = BLOADCOM * FRCCOMAH * FRCFLXCAH
      FLXLDCWH   = BLOADCOM * FRCCOMWH * FRCFLXCWH
      FLXLDCOT   = BLOADCOM * FRCCOMOT * FRCFLXCOT
C
C ***************************************************************************
C      REDUCE COMMERICAL LOAD DUE TO SUPPLYING HEAT/COLD WITH HEAT PUMPS
C ***************************************************************************
C BLOADCOM = 2050 COMMERCIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C ADDCOLD  = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) IN CURRENT SECTOR
C ADDHOT   = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) IN CURRENT SECTOR
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C COLDINFX = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C FRCCOMAC = FRACTION OF COMMERCIAL LOAD THAT IS AC
C FRCCOMRF = FRACTION OF COMMERCIAL LOAD THAT IS REFRIGERATION
C FRCLOWHT = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN RES/COM/GOV BUILDINGS
C            THAT IS FOR LOW-TEMPERATURE HEAT USED IN BUILDINGS (AIR/WATER)
C FRCHTWAT = FRAC OF TOTAL HEAT USED IN BUILDINGS THAT IS USED FOR WATER
C            HEATING. THE REST IS USED FOR AIR HEATING/STOVES
C
      ADDCOLD   = BLOADCOM * FRCCOMAC * (1. - FRCFLXCAC)
     1          + BLOADCOM * FRCCOMRF * (1. - FRCFLXCRF)
      ADDHOT    = BLOADCOM * FRCCOMAH * (1. - FRCFLXCAH)
     1          + BLOADCOM * FRCCOMWH * (1. - FRCFLXCWH)
C
C COLDINFX AND HOTINFLX COULD BE MULTIPLIED BY FRCFLXROT TO GIVE THE
C COLD AND HOT LOAD NOT SUBJECT TO STORAGE THAT IS SUBJECT TO DEMAND
C RESPONSE. OTHERWISE, COLD & HOT LOADS NOT SUBJECT TO STORAGE ARE
C NOT SUBJECT TO DEMAND RESPONSE. THE RESULT WOULD BE ADDED TO TLOADDRM
C
C     COLDINFX  = COLDINFX + ADDCOLD
C     HOTINFLX  = HOTINFLX + ADDHOT
      COLDINFX  = COLDINFX + ADDCOLD * (1. - FRCFLXCOT)
      HOTINFLX  = HOTINFLX + ADDHOT  * (1. - FRCFLXCOT)
      COLDFLEX  = COLDFLEX + ADDCOLD * FRCFLXCOT
      HOTFLEX   = HOTFLEX  + ADDHOT  * FRCFLXCOT
C
C TFLEXCOM   = TOTAL COMMERCIAL FLEXIBLE LOAD (TW) SUBJECT TO STORAGE
C FRCFLEXCOM = FRACTION OF COMMERCIAL LOAD THAT IS FLEXIBLE (0.5218)
C FLXCNOH2 = ANNUAL AVG FLEX COMMERCIAL LOAD (TW) NOT FOR PRODUCING H2
C H2LDCOM  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C FLXELCOM = COMMERCIAL LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C            USED FOR PRODUCING H2
C
      TFLEXCOM   = FLXLDCAC + FLXLDCRF + FLXLDCAH + FLXLDCWH + FLXLDCOT
      FRCFLEXCOM = TFLEXCOM / BLOADCOM
      FLXCNOH2   = TFLEXCOM - H2LDCOM
      FLXELCOM   = FLXLDCOT - H2LDCOM
C
      WRITE(IOUT,138) FRCLOWHT,FRCCOMAH,FRCCOMWH,FRCCOMAC,FRCCOMRF,
     1                FRCCOMOT,
     1                FRCFLXCAH,FRCFLXCWH,FRCFLXCAC,FRCFLXCRF,FRCFLXCOT,
     1                FLXLDCAH, FLXLDCWH, FLXLDCAC, FLXLDCRF,FLXELCOM,
     1                H2LDCOM,  TFLEXCOM, BLOADCOM, FRCFLEXCOM
C
 138  FORMAT('********** COMMERCIAL SECTOR **********'/,
     1      'FRCLOWHT   FRCCOMAH   FRCCOMWH   FRCCOMAC   FRCCOMRF   ',
     1      'FRCCOMOT'/,6(0PF11.4)//,
     1      'FRCFLXCAH  FRCFLXCWH  FRCFLXCAC  FRCFLXCRF  FRCFLXCOT  '/,
     1      5(0PF11.4)//,
     1      'FLXLDCAHTW FLXLDCWH   FLXLDCAC   FLXLDCRF   FLXELCOM   ',
     1      'H2LDCOM    TFLEXCOM   BLOADCOM   FRCFLEXCOM'/,9(1PE11.4)//)
C
C ***************************************************************************
C  FIND FRACTION OF TRANSPORATION LOAD THAT IS FLEXIBLE (EITHER FROM
C                          DRM OR HYDROGEN)
C  H2 FROM 'Efficiency, upstream, electrify' TAB IN '50-States WWS.xlsx' FILE
C ***************************************************************************
C TRANSPORT INCLUDES ALL TRANSPORT ACTIVITIES REGARDLESS OF SECTORS, INCLUDING
C    DOMESTIC AVIATION, ROAD, RAIL, PIPELINE TRANSPORT, DOMESTIC NAVIGATION,
C    & NONSPECIFIED. DOES NOT INCLUDE INTERNATIONAL AVIATION.
C    FOR ROADS, INCLUDES AG & INDUSTRIAL HIGHWAY USE
C    FOR PIPELINES, INCLUDES ENERGY USED IN SUPPORT & OPERATION OF PIPELINES
C    FOR DOMESTIC NAVIGATION, INCLUDES FUELS DELIVERED TO SHIPS NOT INVOLVED IN
C        INTERNATIONAL NAVIGATION
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C BLOADTRA   = 2050 TRANSPORTATION   WWS LOAD (TW) AFTER HEAT PUMPS
C FRCFLEXTRA = FRACTION OF TRANSPORTATION LOAD THAT IS FLEXIBLE (0.85)
C              (SUBJECT TO DEMAND-RESPONSE)
C              INCLUDES ALL LOADS FOR HFCVS, WHICH ARE TREATED
C              AS FLEXIBLE LOADS BUT WITH HIGHER COSTS DUE
C              TO ELECTROLYZER, COMPRESSER, STORAGE, AND FUEL CELL
C TFLEXTRA   = TOTAL EV LOAD (TW) THAT IS FLEXIBLE PLUS ELEC LOAD TO PRODUCE
C              H2 FOR TRANSPORT H2
C EVINFLEX   = ANNUAL AVG ELEC LOAD FOR CHARGING EVS (TW) THAT IS INFLEXIBLE
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C              (ALL LOAD FOR CHARGING H2 FUEL CELL VEHICLES IS FLEXIBLE)
C TFLEXEVS   = FLEXIBLE TRANSPORTATION LOAD FOR ELECTRIC VEHICLES (TW)
C              THE REST OF FLEXIBLE TRANSPORT LOAD IS FOR H2 FOR H2FC VEHICLES
C H2LDTRAN   = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C
      FRCFLEXTRA = 0.85
      TFLEXTRA   = BLOADTRA * FRCFLEXTRA
      TFLEXEVS   = TFLEXTRA - H2LDTRAN
      EVINFLEX   = BLOADTRA - TFLEXTRA
C
      IF (TFLEXEVS.LT.0.) THEN
       WRITE(IOUT,*)'TFLEXEVS<0 INC FRCFLEXTRA ',TFLEXEVS,BLOADTRA,
     1               FRCFLEXTRA,TFLEXTRA,H2LDTRAN
       STOP
      ENDIF
C
      WRITE(IOUT,140) TFLEXEVS, H2LDTRAN, EVINFLEX, BLOADTRA, FRCFLEXTRA
C
 140  FORMAT('********** TRANSPORTATION SECTOR **********'/,
     1      'TFLEXEVS   H2LDTRAN   EVINFLEX   BLOADTRA   FRCFLEXTRA'/,
     1       5(1PE11.4)//)
C
C ***************************************************************************
C FRACTION OF INDUSTRIAL LOAD THAT IS FLEXIBLE OR CAN BE STORED IN TES OR H2
C  H2 FROM 'Efficiency, upstream, electrify' TAB IN '50-States WWS.xlsx' FILE
C ***************************************************************************
C INDUSTRIAL LOADS INCLUDE
C    IRON AND STEEL
C    CHEMICAL AND PETROCHEMICAL (INCL. CRACKING & REFORMING PROCES FOR
C        PROD HC-BASED MATERIALS (E.G., PLASTICS)
C    NON-FERROUS METALS
C    NON-METALLIC MINERALS
C    TRANSPORT EQUIPMENT
C    MINING (EXCLUDING FUELS)
C    MACHINERY
C    FOOD AND TOBACCO
C    PAPER, PULP, AND PRINT
C    WOOD AND WOOD PRODUCTS
C    CONSTRUCTION
C    TEXTILE AND LEATHER
C    NON-SPECIFIED
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C ACFRACTOT = EST FRACTION OF TOTAL AIR HEATING + COOLING ENERGY THAT IS COOLING
C             ENERGY. DO NOT INCLUDE WATER HEATING OR REFRIGERATION SINCE THOSE
C             TEMPERATURES MUST BE RAISED/LOWERED MUCH MORE THAN FOR AIR COMFORT
C FRACHVAC  = FRACTION OF INDUSTRIAL LOAD THAT IS AIR HEATING AND COOLING (HVAC)
C FRACCOOL  = FRACTION OF INDUSTRIAL HVAC THAT IS AIR CONDITIONING
C             (USES AN AVERAGE OF RESIDENTIAL & COMMERCIAL SECTOR VALUES)
C FRCINDAC  = FRACTION OF INDUSTRIAL LOAD THAT IS AIR COOLING
C FRCINDRF  = FRACTION OF INDUSTRY LOAD THAT IS REFRIGERATION
C FRCINDAH  = FRACTION OF INDUSTRIAL LOAD THAT IS AIR HEATING
C FRCINDTR  = FRACTION OF INDUSTRIAL LOAD THAT IS ON-SITE TRANSPORT
C FRCINDHT  = FRACTION OF INDUSTRIAL LOAD THAT IS HI-T, CHEM, OR ELEC PROCS
C
      FRACHVAC  = 0.0624
      FRCINDRF  = 0.024
      FRCINDTR  = 0.0072
C
      IF (IFCONUS.EQ.1) THEN
       FRACCOOL  = 0.15
       FRCINDAC  = FRACHVAC * FRACCOOL
       FRCINDAH  = FRACHVAC * (1. - FRACCOOL)
       FRCINDHT  = 0.8719
      ELSE
       FRCINDAC = MIN(FRACHVAC*ACFRACTOT,FELECREG(IGRIDUSE,IIND)*FMAXAC)
       FRCINDAH = FRACHVAC - FRCINDAC
       FRCINDHT = 1. - FELECREG(IGRIDUSE,IIND)
      ENDIF
C
C FRCINDOT = FRACTION OF INDUSTRIAL LOAD THAT IS OTHER
C
      SUMIND    = FRCINDTR + FRCINDRF + FRCINDAC + FRCINDAH + FRCINDHT
C
      IF (SUMIND.LT.1.) THEN
```

```
       FRCINDOT = 1. - SUMIND
      ELSE
       FRCINDOT = 0.
       FRCINDTR = FRCINDTR / SUMIND
       FRCINDRF = FRCINDRF / SUMIND
       FRCINDAC = FRCINDAC / SUMIND
       FRCINDAH = FRCINDAH / SUMIND
       FRCINDHT = FRCINDHT / SUMIND
      ENDIF
C
C FRCFLXIAC  = FRACTION OF INDUSTRIAL AC LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXIRF  = FRACTION OF INDUSTRIAL REFRIGERATION LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXIAH  = FRACTION OF INDUSTRIAL AIR HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C FRCFLXITR  = FRACTION OF INDUSTRIAL ON-SITE TRANSPORT LOAD THAT IS FLEXIBLE
C              (SUBJECT TO DEMAND-RESPONSE)
C FRCFLXIHT  = FRACTION OF INDUSTRIAL HI-TEMP, CHEM, ELEC PROCS THAT IS FLEXIBLE
C              (SUBJECT TO DEMAND RESPONSE)
C FRCFLXIOT  = FRACTION OF INDUSTRIAL OTHER PROCS THAT ARE FLEXIBLE
C              (SUBJECT TO DEMAND-RESPONSE)
C FDISTHEAT  = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C              USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C              DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C              THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C              HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C              WITHIN BUILDINGS WITH HEAT PUMPS.
C
      FRCFLXIAC = FDISTHEAT
      FRCFLXIRF = FDISTHEAT
      FRCFLXIAH = FDISTHEAT
      FRCFLXITR = 0.85
      FRCFLXIOT = 0.15
C
C ***************************************************************************
C                BRICKS AS HEAT BATTERIES FOR INDUSTRIAL HEAT
C ***************************************************************************
C RONDO: https://rondo.com/how-it-works
C HEAT IS DELIVERED AS SUPERHEATED AIR OR SUPERHEATED STEAM 80-1100C
C PROVIDES HEAT 24/7, 365 DAYS/YEAR
C USED FOR STEEL,CEMENT,CHEMS/PHARMA,MINING,DISTHEAT,PAPER/PULP,ALUMINA
C
C RHB300
C ENERGY STORAGE CAPACIITY: 300 MWh
C PEAK STEAM DISCHARGE RATE: 20 MW
C HOURS OF STORAGE AT PEAK DISCHARGE RATE: 15h
C MAX DAILY OUTPUT: 480 MWh/DAY
C PEAK CHARGE RATE: 70 MW
C HEAT LOSS 1% PER DAY = 0.0417% PER HOUR
C TYPICAL CONNECTION 7.2 kV (3-PHASE ELECTRICAL)
C NUMBER OF CYCLES: UNLIMITED
C CALENDAR LIFE: 40 Y
C ROUND-TRIP EFFICIENCY: 98%
C DISCHARGE TEMPERATURE: 80-1100 C
C DIMENSIONS: 40M-LENGTH X 16M-WIDTH X 14M-HEIGHT (0.64 KM2 FOOTPRINT)
C CAN BE APPLIED TO 90% OF INDUSTRIAL PROCESSES
C
C IFHEATBAT = 1: USE HIGH-TEMP FIREBRICKS FOR HEAT STORAGE FOR INDUSTRY
C                FLEXIBLE & INFLEXIBLE HI-TEMP HEAT LOADS
C HBTDISCH  = MAX DISCHARGE RATE (TW-TH) OF FIREBRICK BATTERIES
C HBTCHARG  = MAX CHARGE RATE (TW-AC) OF FIREBRICK BATTERIES
C           = 3.5 X MAX DISCHARGE RATE FOR RHB300 FOR RONDO DATASHEET
C             MAX CHARGE RATE IS 70 MW-AC; MAX DISCH RATE IS 20 MW-TH
C             ELECTRICITY.
C FRCBRICK  = FRACTION OF INDUSTRIAL LOAD FOR HI-T, CHEM, OR ELEC PROCS
C             THAT IS FOR HI-T AND CAN BE MET BY HI-T BRICK STORAGE
C             FRBRICK + FRCFLXIHT <=1
C FRCFLXIHT = FRACTION OF INDUSTRIAL HI-TEMP, CHEM, ELEC PROCS THAT IS FLEXIBLE
C             (SUBJECT TO DEMAND-RESPONSE) FRBRICK + FRCFLXIHT <=1
C FRCIHFLEX = FRACTION OF INDUSTRIAL LOAD FOR HI-T, CHEM, OR ELEC PROCS
C             THAT CAN BE MET BY HI-T BRICK STORAGE BUT IS NOT MET WITH
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C             SUCH STORAGE SO BECOMES FLEXIBLE (THE REST BECOMES
C             INFLEXIBLE LOAD). APPLIES ONLY WHEN IFHEATBAT=1
C             WHEN IFHEATBAT=1, ALL HEAT NOT SATISFIED BY BRICK STORAGE
C             IS ASSIGNED AS EITHER FLEXIBLE OR INFLEXIBLE, AND ADDED
C             TO FLEX OR INFLEXIBLE DEMAND THAT MUST BE MET WITH
C             ELECTRICITY. THE FLEXIBLE FRACTION IS FRCIHFLEX
C FLXLDIHT  = INDUSTRY HI-T, CHEM, ELEC LOAD (TW) THAT IS FLEXIBLE
C             AND NOT USED TO PRODUCE H2 FOR STEEL OR AMMONIA
C FRCINDHT  = FRACTION OF INDUSTRIAL LOAD THAT IS HI-T, CHEM, OR ELEC PROCS
C             AND NOT USED TO PRODUCE H2 FOR STEEL, AMMONIA
C HOTINDDEM = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C HDISSIP   = RATE HEAT DISSIP (FRAC/HR) FROM HI-T FIREBRICKS DUE TO CONDUCTION
C           = 1%/DAY FROM RONDO DATA SHEET
C           = 0.00041667/HOUR
C H2LDIND   = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C BLOADHIT  = 2050 INDUSTRIAL WWS LOAD (TW) FOR HI-T, CHEM, OR ELEC
C             PROCS, AFTER HEAT PUMPS
C BLOADIND  = 2050 INDUSTRIAL WWS LOAD (TW) AFTER HEAT PUMPS
C
      BLOADHIT   = BLOADIND * FRCINDHT
C
      IF (IFHEATBAT.EQ.1) THEN
       FRCFLXIHT = 0.0
       FRCBRICK  = 0.9
       FLXLDIHT  = BLOADHIT * FRCFLXIHT
       HOTINDDEM = BLOADHIT * FRCBRICK - H2LDIND
       FRCIHFLEX = 0.5
C      FRCIHFLEX = 0.4
C      FRCIHFLEX = 0.3
C      FRCIHFLEX = 0.2
C      FRCIHFLEX = 0.1
C      FRCIHFLEX = 0.0
       HDISSIP   = 0.000416667
C      HDISSIP   = HDISSIP * 2.
C      HDISSIP   = HDISSIP * 3.
C      HDISSIP   = HDISSIP * 4.
C      HDISSIP   = HDISSIP * 5.
C
       IF (HOTINDDEM.LT.0.) THEN
        WRITE(IOUT,*)'HOTINDDEM<0 INC FRCINDHT OR FRCBRICK ',HOTINDDEM,
     1               BLOADIND, FRCINDHT, BLOADHIT,FRCBRICK,H2LDIND
        STOP
       ENDIF
C
      ELSE
       FRCFLXIHT = 0.7
       FRCBRICK  = 0.
       FLXLDIHT  = BLOADHIT * FRCFLXIHT - H2LDIND
       HOTINDDEM = 0.
       FRCIHFLEX = 0.
       HDISSIP   = 0.
C
       IF (FLXLDIHT.LT.0.) THEN
        WRITE(IOUT,*)'FLXLDIHT<0 INC FRCINDHT OR FRCFLXIHT ',FLXLDIHT,
     1               BLOADIND,FRCINDHT,BLOADHIT,FRCFLXIHT,H2LDIND
        STOP
       ENDIF
      ENDIF
C
      HBTDISCH   = HOTINDDEM
      HBTCHARG   = HBTDISCH * 3.5
C
      IF (FRCFLXIHT + FRCBRICK.GT.1.) THEN
       WRITE(IOUT,*)'POWERWORLD: FRCFLXIHT+FRCBRICK>1 ',FRCFLXIHT,
     1              FRCBRICK
       STOP
      ENDIF
C
C BLOADIND = 2050 INDUSTRIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C FLXLDIAC = IND AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDIRF = IND REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDIAH = IND AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDITR = IND ON-SITE TRANSPORT LOAD (TW) THAT IS FLEXIBLE
C FLXLDIHT = INDUSTRY HI-T, CHEM, ELEC LOAD (TW) THAT IS FLEXIBLE
C            AND NOT USED TO PRODUCE H2 FOR STEEL OR AMMONIA
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C FLXLDIOT = IND OTHER ELEC LOAD (TW) THAT IS FLEXIBLE & SUBJECT TO DRM
C
      FLXLDIAC   = BLOADIND * FRCINDAC * FRCFLXIAC
      FLXLDIRF   = BLOADIND * FRCINDRF * FRCFLXIRF
      FLXLDIAH   = BLOADIND * FRCINDAH * FRCFLXIAH
      FLXLDITR   = BLOADIND * FRCINDTR * FRCFLXITR
      FLXLDIOT   = BLOADIND * FRCINDOT * FRCFLXIOT
C
C ***************************************************************************
C REDUCE INDUSTRIAL LOAD DUE TO SUPPLYING LOW-TEMP HEAT/COLD WITH HEAT PUMPS
C ***************************************************************************
C BLOADIND = 2050 INDUSTRIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C ADDCOLD  = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) IN CURRENT SECTOR
C ADDHOT   = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) IN CURRENT SECTOR
C COLDINFX = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C FRCINDAC = FRACTION OF INDUSTRIAL LOAD THAT IS AIR COOLING
C FRCINDRF = FRACTION OF INDUSTRY LOAD THAT IS REFRIGERATION
C FRCINDAH = FRACTION OF INDUSTRIAL LOAD THAT IS AIR HEATING
C
      ADDCOLD   = BLOADIND * FRCINDAC * (1. - FRCFLXIAC)
     1          + BLOADIND * FRCINDRF * (1. - FRCFLXIRF)
      ADDHOT    = BLOADIND * FRCINDAH * (1. - FRCFLXIAH)
C
C COLDINFX AND HOTINFLX COULD BE MULTIPLIED BY FRCFLXROT TO GIVE THE
C COLD AND HOT LOAD NOT SUBJECT TO STORAGE THAT IS SUBJECT TO DEMAND
C RESPONSE. OTHERWISE, COLD & HOT LOADS NOT SUBJECT TO STORAGE ARE
C NOT SUBJECT TO DEMAND RESPONSE. THE RESULT WOULD BE ADDED TO TLOADDRM
C
      COLDINFX  = COLDINFX + ADDCOLD * (1. - FRCFLXIOT)
      HOTINFLX  = HOTINFLX + ADDHOT  * (1. - FRCFLXIOT)
      COLDFLEX  = COLDFLEX + ADDCOLD * FRCFLXIOT
      HOTFLEX   = HOTFLEX  + ADDHOT  * FRCFLXIOT
C
C TFLEXIND   = TOTAL INDUSTRIAL LOAD (TW) THAT IS FLEXIBLE & SUBJECT
C              TO EITHER TES OR DRM OR H2 PROD/STORAGE
C FRCFLEXIND = FRACTION OF INDUSTRIAL LOAD THAT IS FLEXIBLE (0.6877)
C HOTINDDEM  = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C H2LDIND    = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C FLXINOH2   = ANNUAL AVG FLEX INDUSTRIAL LOAD (TW) NOT FOR PRODUCING H2
C
      TFLEXIND   = FLXLDIAC + FLXLDIRF + FLXLDIAH + FLXLDITR + FLXLDIHT
     1           + FLXLDIOT + HOTINDDEM + H2LDIND
      FRCFLEXIND = TFLEXIND / BLOADIND
      FLXINOH2   = TFLEXIND - H2LDIND
C
      WRITE(IOUT,141) FRCINDHT,FRCINDAH,FRCINDAC,FRCINDRF,FRCINDTR,
     1                FRCINDOT,
     1                FRCFLXIHT,FRCFLXIAH,FRCFLXIAC,FRCFLXIRF,FRCFLXITR,
     1                FRCFLXIOT,FRCBRICK,
     1                FLXLDIHT, HOTINDDEM, H2LDIND, FLXLDIAH, FLXLDIAC,
     1                FLXLDIRF, FLXLDITR, FLXLDIOT, TFLEXIND, BLOADIND,
     1                FRCFLEXIND
C
 141  FORMAT('********** INDUSTRIAL SECTOR **********'/,
     1      'FRCINDHT   FRCINDAH    FRCINDAC   FRCINDRF  FRCINDTR   ',
     1      'FRCINDOT'/,6(0PF11.4)//
     1      'FRCFLXIHT  FRCFLXIAH  FRCFLXIAC  FRCFLXIRF  FRCFLXITR   ',
     1      'FRCFLXIOT  FRCBRICK'/,7(0PF11.4)//
     1      'FLXLDIHTTW HOTINDDEM  H2LDIND    FLXLDIAH   FLXLDIAH    '
     1      'FLXLDIRF   FLXDITR    FLXLDIOT   TFLEXIND   BLOADIND    ',
     1      'FRCFLEXIND'/,11(1PE11.4)//)
C
C ***************************************************************************
C      FRACTION OF AGRICULTURAL/FORESTRY/FISHING LOAD THAT IS FLEXIBLE
C           FROM DRM ONLY SINCE NO H2 LOAD FOR THIS SECTOR
C ***************************************************************************
C AG/FORESTRY INCLUDES ENERGY CONSUMED DURING AGRICULTURE/FORESTRY FOR TRACTION
C    (EXCLUDING AG HIGHWAY USE), POWER, AND AGRICULTURAL/DOMESTIC HEATING;
C FISHING INCLUDES FUELS FOR INLAND, COASTAL, DEEP-SEA FISHING. INCLUDES FUELS
C    DELIVERED TO SHIPS OF ALL FLAGS THAT HAVE RE-FUELED IN THE COUNTRY
C    (INCL. INTERNATIONAL FISHING) AS WELL AS ENERGY USED IN THE FISHING INDUSTRY
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C ACFRACTOT = EST FRACTION OF TOTAL AIR HEATING + COOLING ENERGY THAT IS COOLING
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C             ENERGY. DO NOT INCLUDE WATER HEATING OR REFRIGERATION SINCE THOSE
C             TEMPERATURES MUST BE RAISED/LOWERED MUCH MORE THAN FOR AIR COMFORT
C FRCAGFAC  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS AC
C FRCAGFRF  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS REFRIGERATION
C FRCAGFAH  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS AIR HEATING
C FRCAGFWH  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS WATER HEATING
C FRCAGFOT  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS OTHER
C FELECREG  = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C             IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C CDDHDD    = COOLING DEGREE DAYS DIVIED BY HEATING DEGREE DAYS. MULTIPLY
C             FRACTION OF LOAD THAT IS AIR HEATING BY CDDHDD TO OBTAIN
C             FRACTION OF LOAD THAT IS AIR CONDITIONING.
C
      FRCAGFAC  = 0.0791
      FRCAGFAH  = 0.3626
      FRCAGFRF  = 0.0584
      FRCAGFWH  = 0.0768
      RFTOAC    = FRCAGFRF / FRCAGFAC
C
      IF (IFCONUS.EQ.0) THEN
C
C FRCLOWHT = FRACTION OF TOTAL ELEC+HEAT IN SECTOR GOING TO HEAT
C FRCHTWAT = FRACTION OF AIR + WATER HEATING THAT IS WATER HEATING
C
       FRCLOWHT = 1. - FELECREG(IGRIDUSE,IAGFF)
C
C ALL AGRICULTURAL ENERGY IS ELECTRICITY
C
       IF (FRCLOWHT.EQ.0.) THEN
        FRCAGFAC = 0.
        FRCAGFAH = 0.
        FRCAGFRF = 0.
        FRCAGFWH = 0.
C
C SOME ELECTRICITY, SOME HEATING/COOLING
C
       ELSE
        FRACHVAC   = FRCAGFAC + FRCAGFAH
        FRCAGFAC   = FRACHVAC * ACFRACTOT
        FRCAGFAH   = FRACHVAC * (1. - ACFRACTOT)
C
        FRCHTWAT = FRCAGFWH / (FRCAGFWH + FRCAGFAH)
        FRCAGFWH = FRCLOWHT * FRCHTWAT
        FRCAGFAH = FRCLOWHT * (1. - FRCHTWAT)
C
C PARTITION NON-HEATING ENERGY = ELECTRICITY AMONG AC, REFRIGERATION, AND OTHER
C           LIMIT AIR CONDITIONING TO A FRACTION OF TOTAL ELECTRICITY USE
C
        FRCAGFAC  = MIN(FRCAGFAH*CDDHDD,FELECREG(IGRIDUSE,IAGFF)*FMAXAC)
        FRCAGFRF  = FRCAGFAC * RFTOAC
       ENDIF
C      ENDIF FRCLOWHT=0
C
      ENDIF
C     ENDIF IFCONUS=1
C
C FRCAGFOT  = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS OTHER
C
      FRCAGFOT  = 1. - FRCAGFAC - FRCAGFRF - FRCAGFAH - FRCAGFWH
C
C FRCFLXAAC  = FRACTION OF AG/FORESTRY/FISHING AC LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXARF  = FRACTION OF AG/FORESTRY/FISHING REFRIGERATION LOAD THAT IS FLEXIBLE
C              (FROM COLD STORAGE THEN ELECTRICITY). REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FCOLDFLX SUBJECT TO DEM RESP
C FRCFLXAAH  = FRACTION OF AG/FORESTRY/FISHING AIR HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C FRCFLXAWH  = FRACTION OF AG/FORESTRY/FISHING WATER HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C              SINCE ALL WATER IN BUILDINGS IS EITHER STORED IN WATER
C              TANK OR DISTRICT HEAT STORAGE, ALMOST ALL WATER HEATING FLEXIBLE
C FRCFLXAOT  = FRACTION OF AG/FORESTRY/FISHING OTHER LOAD THAT IS FLEXIBLE
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C              (SUBJECT TO DEMAND-RESPONSE)
C FDISTHEAT  = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C              USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C              DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C              THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C              HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C
      FRCFLXAAC = FDISTHEAT
      FRCFLXARF = FDISTHEAT
      FRCFLXAAH = FDISTHEAT
      FRCFLXAWH = 0.95
      FRCFLXAOT = 0.15
C
C BLOADAGF  = 2050 AG/FORESTRY/FISH WWS LOAD (TW) AFTER HEAT PUMPS
C FLXLDAAC  = A/F/F AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDARF  = A/F/F REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAAH  = A/F/F AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAWH  = A/F/F WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAOT  = A/F/F OTHER LOAD (TW) THAT IS FLEXIBLE & SUBJECT TO DRM
C             INCLUDES LOAD USED TO PRODUCE H2 FOR AG/FOR/FISH
C
      FLXLDAAC   = BLOADAGF * FRCAGFAC * FRCFLXAAC
      FLXLDARF   = BLOADAGF * FRCAGFRF * FRCFLXARF
      FLXLDAAH   = BLOADAGF * FRCAGFAH * FRCFLXAAH
      FLXLDAWH   = BLOADAGF * FRCAGFWH * FRCFLXAWH
      FLXLDAOT   = BLOADAGF * FRCAGFOT * FRCFLXAOT
C
C ***************************************************************************
C REDUCE AG/FOR/FISH LOAD DUE TO SUPPLYING LOW-TEMP HEAT/COLD WITH HEAT PUMPS
C ***************************************************************************
C BLOADAGF = 2050 AG/FORESTRY/FISH WWS LOAD (TW) AFTER HEAT PUMPS
C ADDCOLD  = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) IN CURRENT SECTOR
C ADDHOT   = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) IN CURRENT SECTOR
C COLDINFX = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C FRCAGFAC = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS AC
C FRCAGFRF = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS REFRIGERATION
C FRCAGFAH = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS AIR HEATING
C FRCAGFWH = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS WATER HEATING
C FRCAGFOT = FRACTION OF AG/FORESTRY/FISHING LOAD THAT IS OTHER
C
      ADDCOLD   = BLOADAGF * FRCAGFAC * (1. - FRCFLXAAC)
     1          + BLOADAGF * FRCAGFRF * (1. - FRCFLXARF)
      ADDHOT    = BLOADAGF * FRCAGFAH * (1. - FRCFLXAAH)
     1          + BLOADAGF * FRCAGFWH * (1. - FRCFLXAWH)
C
C COLDINFX AND HOTINFLX COULD BE MULTIPLIED BY FRCFLXROT TO GIVE THE
C COLD AND HOT LOAD NOT SUBJECT TO STORAGE THAT IS SUBJECT TO DEMAND
C RESPONSE. OTHERWISE, COLD & HOT LOADS NOT SUBJECT TO STORAGE ARE
C NOT SUBJECT TO DEMAND RESPONSE. THE RESULT WOULD BE ADDED TO TLOADDRM
C
C     COLDINFX  = COLDINFX + ADDCOLD
C     HOTINFLX  = HOTINFLX + ADDHOT
      COLDINFX  = COLDINFX + ADDCOLD * (1. - FRCFLXAOT)
      HOTINFLX  = HOTINFLX + ADDHOT  * (1. - FRCFLXAOT)
      COLDFLEX  = COLDFLEX + ADDCOLD * FRCFLXAOT
      HOTFLEX   = HOTFLEX  + ADDHOT  * FRCFLXAOT
C
C TFLEXAGF   = TOTAL AG/FOR/FISH LOAD (TW) THAT IS FLEXIBLE & SUBJECT
C              TO EITHER TES OR DRM
C FRCFLEXAGF = FRACTION OF AG/FOR/FISH LOAD THAT IS FLEXIBLE (0.85)
C FLXANOH2   = ANNUAL AVG FLEX AG/FOR/FISH LOAD (TW) NOT FOR PRODUCING H2
C H2LDAGR    = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C FLXELAGR   = AG/FOR/FISHLOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C              USED FOR PRODUCING H2
C FLXLDAOT   = A/F/F OTHER LOAD (TW) THAT IS FLEXIBLE & SUBJECT TO DRM
C              INCLUDES LOAD USED TO PRODUCE H2 FOR AG/FOR/FISH
C
      TFLEXAGF   = FLXLDAAC + FLXLDARF + FLXLDAAH + FLXLDAWH + FLXLDAOT
      FRCFLEXAGF = TFLEXAGF / BLOADAGF
      FLXANOH2   = TFLEXAGF - H2LDAGR
      FLXELAGR   = FLXLDAOT - H2LDAGR
C
      WRITE(IOUT,143) FRCAGFAH,FRCAGFWH,FRCAGFAC,FRCAGFRF,FRCAGFOT,
     1                FRCFLXAAH,FRCFLXAWH,FRCFLXAAC,FRCFLXARF,FRCFLXAOT,
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     1               FLXLDAAH, FLXLDAWH, FLXLDAAC, FLXLDARF, FLXELAGR,
     1               H2LDAGR,  TFLEXAGF, BLOADAGF, FRCFLEXAGF
C
 143  FORMAT('********* AGRICULTURE/FORESTRY/FISHING SECTOR *********'/,
     1      'FRCAGFAH   FRCAGFWH   FRCAGFAC   FRCAGFRF   FRCAGFOT'/,
     1       5(0PF11.4)//,
     1      'FRCFLXAAH  FRCFLXAWH  FRCFLXAAC  FRCFLXARF  FRCFLXAOT'/,
     1       5(0PF11.4)//,
     1      'FLXLDAAHTW FLXLDAWH   FLXLDAAC   FLXLDARF   FLXELAGR   ',
     1      'H2LDAGR,   TFLEXAGF   BLOADAGF   FRCFLEXAGF'/,9(0PE11.4)//)
C
C ***************************************************************************
C              FRACTION OF 'OTHER' LOAD THAT IS FLEXIBLE
C             FROM DRM ONLY SINCE NO H2 LOAD FOR THIS SECTOR
C ***************************************************************************
C OTHER INCLUDES RESIDENTIAL, COMMERCIAL AND PUBLIC SERVICES, MILITARY,
C    AND NON-SPECIFIED
C     https://www.iea.org/statistics/resources/balancedefinitions/
C ***************************************************************************
C FRCLOWHT  = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN OTHER SECTOR
C             THAT IS FOR LOW-TEMPERATURE HEAT FOR AIR
C FELECREG  = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C             IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C
      FRCLOWHT   = 1. - FELECREG(IGRIDUSE,IOTH)
C
C FRCFLXOAH  = FRACTION OF OTHER AIR HEATING LOAD THAT IS FLEXIBLE
C              (FROM HEAT STORAGE THEN ELECTRICITY) REST ONLY FROM ELECTRICITY.
C              OF LOAD NOT SATISFIED BY STORAGE, FLEX HEAT SUBJECT TO DEM RESP
C FRCFLEXOTH = FRACTION OF OTHER LOAD THAT IS FLEXIBLE
C              (SUBJECT TO DEMAND-RESPONSE)
C FDISTHEAT  = FRACTION OF TOTAL AIR AND WATER HEAT AND COLD FROM DISTRICT HEATING
C              USING STORAGE IN  UTES (BOREHOLES, WATER PITS, AQUIFERS)
C              DISTRICT HEAT CAN BE SUPPLIED BY HEAT PUMPS OR SOLAR
C              THERMAL HEAT OR GEOTHERMAL HEAT OR EXCESS ELECTRICITY.
C              HEAT/COLD NOT SUPPLIED BY DISTRICT HEATING IS SUPPLIED
C
      FRCFLXOAH  = FDISTHEAT
      FRCFLEXOTH = 0.75
C
C BLOADOTH = 2050 OTHER            WWS LOAD (TW) AFTER HEAT PUMPS
C FLXLDOAH = OTHER AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDOEL = OTHER LOAD (TW) THAT IS ELECTRIC AND FLEXIBLE & SUBJECT TO DRM
C FELECREG = FRAC 2050 END-USE HEAT+ELEC IN EACH SECTOR GOING TO ELECTRICITY
C            IN EACH 1..NUMGRIDS GRID. THE REST GOES TO HEAT
C
      FLXLDOAH   = BLOADOTH * FRCLOWHT                * FRCFLXOAH
      FLXLDOEL   = BLOADOTH * FELECREG(IGRIDUSE,IOTH) * FRCFLEXOTH
C
C ***************************************************************************
C   REDUCE OTHER LOAD DUE TO SUPPLYING LOW-TEMP HEAT/COLD WITH HEAT PUMPS
C ***************************************************************************
C BLOADOTH = 2050 OTHER            WWS LOAD (TW) AFTER HEAT PUMPS
C ADDCOLD  = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) IN CURRENT SECTOR
C ADDHOT   = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) IN CURRENT SECTOR
C COLDINFX = 2050 TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = 2050 TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C FRCLOWHT = FRAC OF TOTAL HEAT+ELEC FINAL ENERGY IN OTHER SECTOR
C            THAT IS FOR LOW-TEMPERATURE HEAT FOR AIR
C
      ADDHOT    = BLOADOTH * FRCLOWHT * (1. - FRCFLXOAH)
C
C COLDINFX AND HOTINFLX COULD BE MULTIPLIED BY FRCFLXROT TO GIVE THE
C COLD AND HOT LOAD NOT SUBJECT TO STORAGE THAT IS SUBJECT TO DEMAND
C RESPONSE. OTHERWISE, COLD & HOT LOADS NOT SUBJECT TO STORAGE ARE
C NOT SUBJECT TO DEMAND RESPONSE. THE RESULT WOULD BE ADDED TO TLOADDRM
C
      HOTINFLX  = HOTINFLX + ADDHOT  * (1. - FRCFLXAOT)
      HOTFLEX   = HOTFLEX  + ADDHOT  * FRCFLXAOT
C
C TFLEXOTH   = TOTAL OTHER LOAD (TW) THAT IS FLEXIBLE & SUBJECT TO DRM
C FLXLDOEL   = OTHER LOAD (TW) THAT IS ELECTRIC AND FLEXIBLE & SUBJECT TO DRM
C              THIS INCLUDES LOAD FOR PRODUCING H2 IN OTHER SECTOR
C FLXLDOAH   = OTHER AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXONOH2   = ANNUAL AVG FLEX OTHER LOAD (TW) NOT FOR PRODUCING H2
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C H2LDOTH    = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C FRCFLEXOTH = FRACTION OF OTHER ENERGY LOAD THAT IS FLEXIBLE
C FLXELOTH   = OTHER LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C              USED FOR PRODUCING H2
C
      TFLEXOTH   = FLXLDOEL + FLXLDOAH
      FRCFLEXOTH = TFLEXOTH / BLOADOTH
      FLXONOH2   = TFLEXOTH - H2LDOTH
      FLXELOTH   = FLXLDOEL - H2LDOTH
C
      IF (FLXELOTH.LT.0.) THEN
       WRITE(IOUT,*)'FLXELOTH<0 INC FLXLDOEL ',FLXELOTH,FLXLDOEL,H2LDOTH
       STOP
      ENDIF
C
      WRITE(IOUT,145) FRCLOWHT,
     1        FRCFLXOAH,FRCFLEXOTH,
     1        FLXLDOAH, FLXELOTH, H2LDOTH,TFLEXOTH,BLOADOTH,FRCFLEXOTH
C
 145  FORMAT('********** OTHER SECTOR **********'/,
     1       'FRLOWHT'/,1(0PF11.4)//,
     1       'FRCFLXOAH  FRCFLEXOTH'/,2(0PF11.4)//,
     1       'FLXLDOAHTW FLXELOTH   H2LDOTH    FLXLDOEL   TFLEXOTH   ',
     1       'BLOADOTH   FRCFLEXOTH '/,
     1        6(1PE11.4)//)
C
C ***************************************************************************
C  SUM AIR CONDITIONING, REFRIGERATION, HEATING LOADS SUBJECT TO THERMAL-ENERGY
C     STORAGE. SUM OTHER FLEXIBLE LOADS FOR DEMAND-RESPONSE MANAGEMENT
C  THESE NUMBERS DO NOT INCLUDE HEATING, COOLING THAT IS PART OF INFLEXIBLE
C  ELECTRICITY LOAD OR HIGH-TEMPERATURE INDUSTRIAL HEAT
C ***************************************************************************
C                                 COOLING
C ***************************************************************************
C TSTORAIRC = AVG ANNUAL LOAD (TW) FOR AIR COOLING (TW) SUBJECT TO STORAGE
C FLXLDRAC  = RES AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCAC  = COM AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDIAC  = IND AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAAC  = A/F/F AC LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C
      TSTORAIRC  = FLXLDRAC + FLXLDCAC + FLXLDIAC + FLXLDAAC
C
C TSTORREFR = AVG ANNUAL LOAD (TW) FOR REFRIGERATION SUBJECT TO STORAGE
C FLXLDCRF  = COM REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDIRF  = IND REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDARF  = A/F/F REFRIGERATION LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C
      TSTORREFR  = FLXLDCRF + FLXLDIRF + FLXLDARF
C
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C
      TSTORCOOL  = TSTORAIRC + TSTORREFR
C
C COOLSTES = FRACTION OF AIR CONDITIONING PLUS REFRIGERATION LOAD FROM
C            CHILLED WATER (CW-STES). THE REST IS FROM PCM-ICE
C
      COOLSTES = 0.4
C
C CHILDISCH = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C
      CHILDISCH = TSTORCOOL * COOLSTES
      PCMDISCH  = TSTORCOOL - CHILDISCH
C
C ***************************************************************************
C                                 HEATING
C ***************************************************************************
C TSTORAIRH = TOTAL LOAD (TW) FOR AIR HEATING SUBJECT TO STORAGE
C FLXLDRAH  = RES AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCAH  = COM AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDIAH  = IND AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAAH  = A/F/F AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDOAH  = OTHER AIR HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C
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      TSTORAIRH  = FLXLDRAH + FLXLDCAH + FLXLDIAH + FLXLDAAH + FLXLDOAH
C
C TSTORWATH = TOTAL FLEX LOAD (TW) FOR WATER HEATING SUBJECT TO STORAGE
C FLXLDRWH  = RES WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDCWH  = COM WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C FLXLDAWH  = A/F/F WATER HEAT LOAD (TW) THAT IS FLEXIBLE (DESIGNED WITH TES)
C
      TSTORWATH  = FLXLDRWH  + FLXLDCWH + FLXLDAWH
C
C TSTORAWH  = TOTAL LOAD (TW) FOR LOW-TEMP AIR AND WATER HEATING SUBJ TO STORAGE
C
      TSTORAWH   = TSTORAIRH + TSTORWATH
C
C TOTCOLD  = TOTAL ANNUAL-AVG BUILDING COLD LOAD AMONG ALL SECTORS (TW)
C TOTHOT   = TOTAL ANNUAL-AVG BUILDING HEAT LOAD AMONG ALL SECTORS (TW)
C COLDINFX = ANNUAL AVG TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C HOTINFLX = ANNUAL AVG TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C COLDFLEX = PORTION OF COLD LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C HOTFLEX  = PORTION OF WARM LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C
      TOTCOLD    = TSTORCOOL + COLDINFX + COLDFLEX
      TOTHOT     = TSTORAWH  + HOTINFLX + HOTFLEX
C
      IF (IFGATHEAT.EQ.1) THEN
       WRITE(IOUT,120)TOTCOLD,AVCOLDLD(1),TOTHOT,AVHEATLD(1),
     1                CDDHDD,ACFRACTOT,FRCOLD,FRWARM,COLDFAC,WARMFAC
      ELSE
       WRITE(IOUT,135)TOTCOLD,AVGCDD(IGRIDUSE),TOTHOT,AVGHDD(IGRIDUSE),
     1                CDDHDD,ACFRACTOT,0.,0.,0.,0.
      ENDIF
C
 120  FORMAT('TOTCOLD-TW AVCOLLD-TW TOTHOT-TW  AVHOTLD-TW CDDHDD     ',
     1       'ACFRACTOT'/,6(0PF11.4)/,
     1       'FRCOLD    FRWARM      COLDFAC    WARMFAC'/,4(0PF11.4)/)
C
 135  FORMAT('TOTCOLD-TW AVGCDD-F   TOTHOT-TW AVGHDD-F   CDDHDD     ',
     1       'ACFRACTOT '/,6(0PF11.4)/,
     1       'FRCOLD    FRWARM      COLDFAC    WARMFAC'/,4(0PF11.4)/)
C
C ***************************************************************************
C             MONTHLY VARIATION OF HEATING/COOLING LOADS IN U.S.
C ***************************************************************************
C
      COOLMAX  = 0.
      WARMMAX  = 0.
C
C HDDYEAR   = HEATING DEGREE DAYS PER YEAR (F) = 4524
C CDDYEAR   = COOLING DEGREE DAYS PER YEAR (F) = 1216
C HDDMON    = HEATING DEGREE DAYS PER MONTH (F)
C           = DEVIATIONS BELOW MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C             ALL DAYS IN MONTH
C CDDMON    = COOLING DEGREE DAYS PER MONTH (F)
C           = DEVIATIONS ABOVE MEAN DAILY TEMPERATURE OF 65 F SUMMED OVER
C             ALL DAYS IN MONTH
C
      IF (IFCONUS.EQ.1) THEN
C
       HDDYEAR     = 0.
       CDDYEAR     = 0.
C
       DO I        = 1, MXMONTH
        HDDYEAR    = HDDYEAR + HDDMON(I)
        CDDYEAR    = CDDYEAR + CDDMON(I)
       ENDDO
C
C FRDAYCOOL = FRAC OF YEARLY AIR COOLING + REFRIG THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-COOLING DAYS ON DAY
C FRDAYWARM = FRAC OF YEARLY AIR & WATER HEATING THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-HEATING DAYS ON DAY
C TSTORCOOL = ANNUAL AVG LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C TSTORAWH  = ANNUAL AVG LOAD (TW) FOR AIR AND WATER HEATING SUBJECT TO STORAGE
C WARMMAX   = MAX LOW-TEMP HEATING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING SIM PERIOD
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C             (ALREADY CONVERTED TO ELECTRICAL LOAD THAT WOULD PRODUCE THAT HEAT
C             LOAD, ASSUMING HEAT PUMPS RUNNING ON ELECTRICITY, IN
C             countrystats.dat)
C COOLMAX   = MAX COOLING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING  SIMULATION PERIOD
C TCOOLMON  = FLEXIBLE COOLING LOAD ON ANY DAY IN CURRENT MONTH OF YEAR (TW)
C TWARMMON  = FLEXIBLE HEATING LOAD ON ANY DAY IN CURRENT MONTH OF YEAR (TW)
C LDMONTH   = NUMBER OF DAYS IN A MONTH
C NDAYYR    = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C
       DO N             = 1, NYEARS
        DO I            = 1, MXMONTH
         FRDAYCOOL(N,I) = CDDMON(I) / (CDDYEAR * LDMONTH(N,I))
         FRDAYWARM(N,I) = HDDMON(I) / (HDDYEAR * LDMONTH(N,I))
         TCOOLMON       = TSTORCOOL * NDAYYR(N) * FRDAYCOOL(N,I)
         TWARMMON       = TSTORAWH  * NDAYYR(N) * FRDAYWARM(N,I)
         COOLMAX        = MAX(COOLMAX,TCOOLMON)
         WARMMAX        = MAX(WARMMAX,TWARMMON)
        ENDDO
       ENDDO
C
      ELSE
C     ELSEIF IFCONUS=0
C
C NDAYYR    = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C LDMONTH   = NUM DAYS IN MONTH (ACCOUNTING FOR LEAP DAYS) FOR EACH YEAR OF SIM
C HDDREG    = HEATING DEGREE DAYS PER DAY (F) FOR REGION J = 1, NUMGRIDS
C CDDREG    = COOLING DEGREE DAYS PER DAY (F) FOR REGION J = 1, NUMGRIDS
C NDAYYR    = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C FRDAYCOOL = FRAC OF YEARLY AIR COOLING + REFRIG THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-COOLING DAYS ON DAY
C FRDAYWARM = FRAC OF YEARLY AIR & WATER HEATING THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-HEATING DAYS ON DAY
C TCOOLMON  = FLEXIBLE COOLING LOAD ON ANY DAY IN CURRENT DAY OF YEAR (TW)
C TWARMMON  = FLEXIBLE HEATING LOAD ON ANY DAY IN CURRENT DAY OF YEAR (TW)
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C TSTORAWH  = ANNUAL LOAD (TW) FOR AIR AND WATER HEATING SUBJECT TO STORAGE
C TWARMDAY  = LOAD ON SPECIFIC DAY OF YEAR (TW) FOR WARMING (AIR AND WATER)
C WARMMAX   = MAX LOW-TEMP HEATING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING SIM PERIOD
C             (ALREADY CONVERTED TO ELECTRICAL LOAD THAT WOULD PRODUCE THAT HEAT
C             LOAD, ASSUMING HEAT PUMPS RUNNING ON ELECTRICITY, IN
C             countrystats.dat)
C COOLMAX   = MAX COOLING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING  SIMULATION PERIOD
C HDDYR     = NUMBER OF HEATING DEGREE DAYS PER YEAR. DIVIDE BY NDAYYR
C             TO OBTAIN YEARLY-AVG NUMBER OF HEATING DEGREE DAYS PER DAY.
C HCDDADD   = ADD DUMMY HEATING AND COOLING DEGREE DAYS FOR EACH DAY OF
C             YEAR TO ENSURE MAXIMUM VALUES FOR COUNTRIES THAT HAVE FEW
C             HDD OR CDD DAYS DON'T RESULT IN ALL HEATING OR COOLING
C             FALLING ON ONE DAY. IN REALITY, SOME HEATING LOAD SHOULD
C             BE SPREAD OVER EVERY NIGHT FOR AIR AND WATER HEATING.
C             SIMILARLY, SOME COOLING OCCURS EVERY DAY FOR REFRIGERATION
C             ENSURE THAT HDDREG AND CDDREG HAVE A MINIMUM VALUE EACH DAYS BECAUSE
C             1) PEOPLE USE COLD AIR/WATER FOR REFRIG, COMPUTER COOLING EVEN IF DAY COLD
C                AND HOT AIR/WATER FOR SHOWERS, COOKING EVEN IF DAY IS HOT
C             2) IF HDDREG OR CDDREG = 0 EVERY DAY OF YEAR, THEN HEAT OR COLD LOAD IS
C                SET TO ZERO EVERY DAY ALTHOUGH A LOAD MAY ACTUALLY EXIST
C             3) IF HDDREG>0 ONLY ON ONE DAY OF YEAR, THE MAXIMUM HEAT LOAD = 365*TSTORAWH
C                SAME WITH COLD LOAD
C
       DO N         = 1, NYEARS
        HDDYR(N)    = 0.
        CDDYR(N)    = 0.
C
C NOTE THAT HDDREG AND CDDREG HAVE MIN VALS DEGDAYMIN, SO HDDYR, CDDYR NEVER 0
C
        DO I        = 1, NDAYYR(N)
         HDDYR(N)   = HDDYR(N) + HDDREG(IGRIDUSE,N,I) + HCDDADD
         CDDYR(N)   = CDDYR(N) + CDDREG(IGRIDUSE,N,I) + HCDDADD
        ENDDO
C
        DO I            = 1, NDAYYR(N)
         FRDAYCOOL(N,I) = (CDDREG(IGRIDUSE,N,I) + HCDDADD) / CDDYR(N)
         FRDAYWARM(N,I) = (HDDREG(IGRIDUSE,N,I) + HCDDADD) / HDDYR(N)
         TCOOLDAY1      = TSTORCOOL * NDAYYR(N) * FRDAYCOOL(N,I)
         TWARMDAY1      = TSTORAWH  * NDAYYR(N) * FRDAYWARM(N,I)
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         COOLMAX        = MAX(COOLMAX,TCOOLDAY1)
         WARMMAX        = MAX(WARMMAX,TWARMDAY1)
        ENDDO
C
       ENDDO
C      ENDDO N = 1, NYEARS
C
      ENDIF
C     ENDIF IFCONUS=1
C
C ***************************************************************************
C                 OVERRIDE WARMMAX, COOLMAX WHEN IFGATHEAT=1
C ***************************************************************************
C WARMMAX   = MAX LOW-TEMP HEATING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING SIM PERIOD
C             (ALREADY CONVERTED TO ELECTRICAL LOAD THAT WOULD PRODUCE THAT HEAT
C             LOAD, ASSUMING HEAT PUMPS RUNNING ON ELECTRICITY, IN
C             countrystats.dat)
C COOLMAX   = MAX COOLING LOAD SUBJ TO STORAGE (TW) ANY TIME DURING  SIMULATION PERIOD
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C TSTORAWH  = ANNUAL LOAD (TW) FOR AIR AND WATER HEATING SUBJECT TO STORAGE
C CURCOLD   = CURRENT BUILDING END-USE COLD LOAD (TW) FOR REGION FROM GATOR-GCMOM
C CURHEAT   = CURRENT BUILDING END-USE HEAT LOAD (TW) FOR REGION FROM GATOR-GCMOM
C AVHEATLD  = ANNUAL AVG BUILDING HEAT LOAD (TW) OVER ENTIRE KWWS DATASET
C AVCOLDLD  = ANNUAL AVG BUILDING COLD LOAD (TW) OVER ENTIRE KWWS DATASET
C FSTPCOOL  = FRAC OF ANNUAL AVG COLD LOAD OCCURRING IN GIVEN TIME STEP
C FSTPWARM  = FRAC OF ANNUAL AVG WARM LOAD OCCURRING IN GIVEN TIME STEP
C FSTPVEH   = FRAC OF AN AVG FLEX EV (NOT H2FCV) LOAD OCCURRING IN GIVEN TIME STEP
C TIMWWS    = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C ITZONE    = TIME ZONE (HR) OF CURRENT LONGITUDE (-12 TO +12)
C LOCHR     = LOCAL STANDARD TIME HOUR (1..24)
C VEHRAT    = RATIO OF CHARGING IN GIVEN HOUR TO DAILY-AVG CHARGING
C             VALUES MUST ADD TO 1
C
      IF (IFGATHEAT.EQ.1) THEN
       COOLMAX       = 0.
       WARMMAX       = 0.
       DO J          = 1, IWWS
        IYY          = IYRWWS(J)
        IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
         FSTPCOOL(J) = CURCOLD(J) / AVCOLDLD(IYY)
         FSTPWARM(J) = CURHEAT(J) / AVHEATLD(IYY)
         TCOOLDAY1   = TSTORCOOL * FSTPCOOL(J)
         TWARMDAY1   = TSTORAWH  * FSTPWARM(J)
         COOLMAX     = MAX(COOLMAX,TCOOLDAY1)
         WARMMAX     = MAX(WARMMAX,TWARMDAY1)
C
         LOCHR1      = TIMWWS(J) + ITZONE
         LOCHR       = MOD(LOCHR1+24,24) + 1
         FSTPVEH( J) = VEHRAT(LOCHR)
        ENDIF
       ENDDO
      ENDIF
C     ENDIF IFGATHEAT=1
C
C ***************************************************************************
C             SET SOIL STORAGE CHARGING/DISCHARGING RATES
C ***************************************************************************
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C           = MAX HEAT LOAD
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C             THUS, NO NEED TO ADJUST UTESCHARG WITH CPERFORM, SINCE
C             UTES STORAGE IS ALREADY EFFECTIVE ELECTRICAL STORAGE
C UTESCHARG = MAX CHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             FROM EXCESS ELECTRIC POWER GENERATION
C             SINCE LOW-TEMP HEAT LOAD IN countrystats.dat ALREADY
C             CONVERTED TO EQUIVALENT ELECTRICAL LOAD ASSUMING
C             HEAT PUMPS WITH CPERFORM, UTESCCHARG IS REALLY THE CHARGE
C             RATE OF EQUIV ELECTRICITY TO GIVE HEATING FROM HEAT PUMPS
C CPERFORM  = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C            (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C           = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
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C           = 1 FOR ELECTRIC RESISTANCE HEATING
C           = 3.2-4.5 FOR AIR SOURCE HEAT PUMPS
C           = 4.2-5.2 FOR GROUND SOURCE HEAT PUMPS
C STORUGHRS = HOURS OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL (UTES) (HRS)
C WARMMAX   = MAX LOW-TEMPERATURE HEATING LOAD ANY DAY OF YEAR (TW)
C             (ALREADY CONVERTED TO ELECTRICAL LOAD THAT WOULD PRODUCE THAT HEAT
C             LOAD, ASSUMING HEAT PUMPS RUNNING ON ELECTRICITY, IN
C             countrystats.dat)
C UGFAC     = FACTOR TO MULTIPLY UTESCHARG BY TO INCREASE OR DECREASE
C             CHARGE RATE OF UTES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN GO ABOVE 1. HIGHER UGFAC-->MORE
C             EXPENSIVE COST OF HEAT PUMPS TO CHARGE STORAGE WITH
C             ELECTRICITY. IF UGFAC=0, THEN ONLY SOLAR COLLECTORS
C             (FACSHT) CAN SUPPLY UTES WITH HEAT .
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C COOLSTES  = FRACTION OF AIR CONDITIONING PLUS REFRIGERATION LOAD FROM
C             CHILLED WATER (CW-STES). THE REST IS FROM PCM-ICE
C FRCIHFLEX = FRACTION OF INDUSTRIAL LOAD FOR HI-T, CHEM, OR ELEC PROCS
C             THAT CAN BE MET BY HI-T BRICK STORAGE BUT IS NOT MET WITH
C             SUCH STORAGE SO BECOMES FLEXIBLE (THE REST BECOMES
C             INFLEXIBLE LOAD). APPLIES ONLY WHEN IFHEATBAT=1
C FHEATFLX = FRACTION OF HEAT LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY HEAT STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C FCOLDFLX = FRACTION OF COLD LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY COLD STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C
      IF (STORUGDYS.GT.0.) THEN
       UTESDISCH  = WARMMAX
       UTESCHARG  = WARMMAX * UGFAC
      ELSE
       UTESDISCH  = 0.
       UTESCHARG  = 0.
      ENDIF
C
      WRITE(IOUT,167)TSTORCOOL*1E3,COOLMAX*1E3,TSTORAWH*1E3,WARMMAX*1E3,
     1               COOLSTES,FHEATFLX,FCOLDFLX,FRCIHFLEX
 167  FORMAT('AVGCOOLING MAXCOOLING-GW  AVGHEATING MAXHEATING-GW '/,
     1        4(0PF11.5)/
     1        'COOLSTES   FHEATFLX   FCOLDFLX   FRCIHIFLEX'/4(0PF11.5))
C
C HOTDISCH  = MAX DISCHARGE RATE (TW) OF HOT WATER (HW)-STES
C             REALLY MAX DISCHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
C HOTCHARG  = MAX CHARGE RATE (TW) OF HOT WATER (HW)-STES
C             REALLY MAX CHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
C HWFAC     = FACTOR TO MULTIPLY HOTCHARGE BY TO INCREASE OR DECREASE
C             CHARGE RATE OF HW-STES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN BE ABOVE 1.
C
      HOTDISCH   = WARMMAX
      HOTCHARG   = WARMMAX * HWFAC
C
C ***************************************************************************
C                   SET LOAD SUBJECT TO DEMAND-RESPONSE
C          THESE ARE LOADS ASIDE FROM LOW-TEMPERATURE HEATING LOADS
C ***************************************************************************
C TLOADDRM = TOTAL LOAD (TW) SUBJECT TO DEMAND-RESPONSE MANAGEMENT
C            AND NOT USED TO PRODUCE H2 OR TO SUPPLY DISTRICT HEAT/COLD
C TFLEXEVS = FLEXIBLE TRANSPORTATION LOAD FOR ELECTRIC VEHICLES (TW)
C            THE REST OF FLEXIBLE TRANSPORT LOAD IS FOR H2 FOR H2FC VEHICLES
C FLXLDITR = INDUSTRY ON-SITE TRANSPORT LOAD (TW) THAT IS FLEXIBLE
C FLXLDIHT = INDUSTRY HI-T, CHEM, ELEC LOAD (TW) THAT IS FLEXIBLE
C            AND NOT USED TO PRODUCE H2 FOR STEEL OR AMMONIA
C FLXLDIOT = INDUSTRY OTHER ELEC LOAD (TW) THAT IS FLEXIBLE & SUBJECT TO DRM
C FLXELRES = RESIDENTIAL LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C            USED FOR PRODUCING H2
C FLXELCOM = COMMERCIAL LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
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C            USED FOR PRODUCING H2
C FLXELAGR = AG/FOR/FISH LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C            USED FOR PRODUCING H2
C FLXELOTH = OTHER LOAD (TW) THAT IS ELECTRIC+SUBJECT TO DRM BUT NOT
C            USED FOR PRODUCING H2
C COLDFLEX = PORTION OF COLD LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C HOTFLEX  = PORTION OF WARM LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C
      TLOADDRM   = TFLEXEVS + FLXLDITR + FLXLDIHT + FLXLDIOT
     1           + FLXELRES + FLXELCOM + FLXELAGR + FLXELOTH
     1           + COLDFLEX + HOTFLEX
C
C ***************************************************************************
C     IF USING HEAT PUMPS, RECALCULATE TOTAL LOAD, WHICH WILL BE LOWER NOW
C ***************************************************************************
C TLOAD2050 = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C TLFIN2050 = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C BLOADRES  = 2050 RESIDENTIAL      WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADCOM  = 2050 COMMERCIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADIND  = 2050 INDUSTRIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADTRA  = 2050 TRANSPORTATION   WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADAGF  = 2050 AG/FORESTRY/FISH WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADOTH  = 2050 OTHER            WWS LOAD (TW) AFTER HEAT PUMPS
C DECLOAD   = TLOAD2050 - TLFIN2050 SHOULD = 0.
C CPERFORM  = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C            (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C           = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
C
      TLFIN2050 = BLOADRES+BLOADCOM+BLOADIND+BLOADTRA+BLOADAGF+BLOADOTH
      DECLOAD   = TLOAD2050 - TLFIN2050
C
      WRITE(IOUT,160) TLOAD2050*GWPTW,TLFIN2050*GWPTW,
     1                BLOADRES *GWPTW,BLOADRES *GWPTW,
     1                BLOADCOM *GWPTW,BLOADCOM *GWPTW,
     1                BLOADTRA *GWPTW,BLOADTRA *GWPTW,
     1                BLOADIND *GWPTW,BLOADIND *GWPTW,
     1                BLOADAGF *GWPTW,BLOADAGF *GWPTW,
     1                BLOADOTH *GWPTW,BLOADOTH *GWPTW,
     1                FDISTHEAT, FMORTBAU,
     1                CPERFORM,  CPERF1,
     1                DECLOAD*GWPTW
 160  FORMAT(/
     1  'ALL-PURPOSE LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'RESIDENTIAL LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'COMMERCIAL  LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'TRANSPORT   LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'INDUSTRIAL  LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'AG/FOR/FISH LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'OTHER       LOAD (GW) BEF/AFT HEAT PUMPS       = ',2(0PF12.6),/
     1  'FDISTHEAT-FRAC HEAT,COLD THAT IS DH, FMORTBAU  = ',2(0PF12.6),/
     1  'HEAT PUMP COEFFICIENT OF PERFORMANCE, CPERF1   = ',2(0PF12.6),/
     1  'DECLOAD (GW) SHOULD = 0                        = ',0PF12.6,/)
C
C ***************************************************************************
C                  CALCULATE TOTAL FLEXIBLE & INFLEXIBLE LOADS
C ***************************************************************************
C TLOADFLEX  = TOTAL FLEXIBLE LOAD (TW) 2050 WITH WWS
C              INCLUDES LOADS SUBJECT TO STORAGE, DEMAND-RESPONSE, AND H2 PROD
C TSTORCOOL  = ANNUAL AVG LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C            = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C              DOES NOT INCLUDE ELECCOLD (INFLEX COLD LOAD)
C TSTORAWH   = ANNUAL AVG LOAD (TW) FOR AIR+WATER HEATING SUBJECT TO STORAGE
C              DOES NOT INCLUDE ELECHOT (INFLEX HEAT LOAD)
C TLOADDRM   = TOTAL LOAD (TW) SUBJECT TO DEMAND-RESPONSE MANAGEMENT
C TLOADH2    = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE
C TLOADINFX  = TOTALINFLEXIBLE LOAD IN 2050 WITH WWS (TW)
C FRCFLEXALL = FRACTION OF TOTAL 2050 LOAD THAT IS FLEXIBLE
C TWHH2RE    = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR
C              RESIDENTIAL SECTOR FROM 2050 50-STATE PLAN
C TWHH2CO    = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR
C              COMMERCIAL SECTOR FROM 2050 50-STATE PLAN
C TWHH2TR    = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR TRANSPORT
C              FROM 2050 50-STATE PLAN
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C TWHH2IN    = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR INDUSTRY
C              FROM 2050 50-STATE PLAN
C TWHH2TOT   = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C              THIS NUMBER ACCOUNTS FOR LEAKED HYDROGEN
C FRCH2ALL   = FRAC OF ALL-SECTOR 2050 LOAD USED TO PRODUCE/COMPRESS/STORE H2
C TLOAD2050  = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C TLFIN2050  = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C HOTINDDEM  = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C
      TLOADFLEX  = TSTORCOOL + TSTORAWH + TLOADDRM + TLOADH2 + HOTINDDEM
      TLOADINFX  = TLFIN2050 - TLOADFLEX
C
      FRCFLEXALL = TLOADFLEX / TLFIN2050
      FRCH2ALL   = TWHH2TOT  / (TLFIN2050 * HRSPYR)
C
C COLDINFX  = ANNUAL AVG TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C             CALCULATED AFTER HEAT PUMPS HAVE BEEN ACCOUNTED FOR
C HOTINFLX  = ANNUAL AVG TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C             CALCULATED AFTER HEAT PUMPS HAVE BEEN ACCOUNTED FOR
C ELECCOLD  = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C ELECHOT   = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
C EVINFLEX  = ANNUAL AVG ELEC LOAD FOR CHARGING EVS (TW) THAT IS INFLEXIBLE
C             (ALL LOAD FOR CHARGING H2 FUEL CELL VEHICLES IS FLEXIBLE)
C TNONHC    = ANNUAL AVG TOTAL INFLEXIBLE LOAD (TW) THAT IS NOT HOT OR COLD LOAD
C             OR HI-T HEAT LOAD SUBJECT TO BRICK STORAGE
C
      ELECCOLD    = COLDINFX
      ELECHOT     = HOTINFLX
      TNONHC      = TLOADINFX - ELECCOLD - ELECHOT
C
C ***************************************************************************
C                 PRINT LOAD AND H2 STATISTICS BY SECTOR
C ***************************************************************************
C TLFIN2050 = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C BLOADRES  = 2050 RESIDENTIAL      WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADCOM  = 2050 COMMERCIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADIND  = 2050 INDUSTRIAL       WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADTRA  = 2050 TRANSPORTATION   WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADAGF  = 2050 AG/FORESTRY/FISH WWS LOAD (TW) AFTER HEAT PUMPS
C BLOADOTH  = 2050 OTHER            WWS LOAD (TW) AFTER HEAT PUMPS
C HOTINDDEM = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C
      WRITE(IOUT,184) TLFIN2050*GWPTW,TLOADINFX*GWPTW,TLOADFLEX*GWPTW,
     1                TSTORCOOL*GWPTW,TSTORAWH *GWPTW,TLOADDRM *GWPTW,
     1                TLOADH2  *GWPTW, HOTINDDEM*GWPTW
 184  FORMAT('TLFIN2050-GW TLOADINFX TLOADFLEX TSTORCOOL  TSTORAWH   ',
     1       'TLOADDRM     TLOADH2   HOTINDDEM',/8(0PF11.5)/)
C
      WRITE(IOUT,169) BLOADRES *GWPTW, BLOADCOM*GWPTW, BLOADIND*GWPTW,
     1                BLOADTRA *GWPTW, BLOADAGF*GWPTW, BLOADOTH*GWPTW,
     1                TLFIN2050*GWPTW
 169  FORMAT('BLOADRES-GW BLOADCOM  BLOADIND   BLOADTRA   BLOADAGF   ',
     1       'BLOADOTH    BLFIN2050 '/,7(0PF11.4)/)
C
C TFLEXTRA = TOTAL EV LOAD (TW) THAT IS FLEXIBLE PLUS ELEC LOAD TO PRODUCE
C            H2 FOR TRANSPORT H2
C EVINFLEX = ANNUAL AVG ELEC LOAD FOR CHARGING EVS (TW) THAT IS INFLEXIBLE
C            (ALL LOAD FOR CHARGING H2 FUEL CELL VEHICLES IS FLEXIBLE)
C FLXRNOH2 = ANNUAL AVG FLEX RESIDENTIAL LOAD (TW) NOT FOR PRODUCING  H2
C FLXCNOH2 = ANNUAL AVG FLEX COMMERCIAL LOAD (TW) NOT FOR PRODUCING H2
C FLXINOH2 = ANNUAL AVG FLEX INDUSTRIAL LOAD (TW) NOT FOR PRODUCING H2
C TFLEXEVS = ANNUAL AVG FLEX TRANSPORT LOAD (TW) NOT FOR PRODUCING H2
C            TFLEXEVS IS ELEC USED FOR BATTERY-ELECTRIC VEHICLES
C FLXANOH2 = ANNUAL AVG FLEX AG/FOR/FISH LOAD (TW) NOT FOR PRODUCING H2
C FLXONOH2 = ANNUAL AVG FLEX OTHER LOAD (TW) NOT FOR PRODUCING H2
C H2LDRES  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDCOM  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDIND  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDTRAN = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDAGR  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C H2LDOTH  = AVG ELEC LOAD (TW) FOR TRANSPORT H2 PROD/COMPRESSION/STORAGE
C TLOADH2  = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE
C
      WRITE(IOUT,170)
     1             TFLEXRES*GWPTW,  FLXRNOH2*GWPTW,
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     1               H2LDRES*GWPTW, TWHH2RE, FRACREH2,
     1            TFLEXCOM*GWPTW,  FLXCNOH2*GWPTW,
     1               H2LDCOM*GWPTW, TWHH2CO, FRACCOH2,
     1            TFLEXIND*GWPTW,  FLXINOH2*GWPTW,
     1               H2LDIND*GWPTW, TWHH2IN, FRACINH2,
     1            TFLEXTRA*GWPTW,  TFLEXEVS*GWPTW,
     1               H2LDTRAN*GWPTW, TWHH2TR, FRACTRH2,
     1            TFLEXAGF*GWPTW,  FLXANOH2*GWPTW,
     1               H2LDAGR *GWPTW, TWHH2AG, FRACAGH2,
     1            TFLEXOTH*GWPTW,  FLXONOH2*GWPTW,
     1               H2LDOTH*GWPTW, TWHH2OT, FRACOTH2,
     1            TLOADFLEX*GWPTW, (TLOADFLEX-TLOADH2)*GWPTW,
     1               TLOADH2*GWPTW, TWHH2TOT, FRCH2ALL
C
 170  FORMAT(
     1  'GWRES-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWCOM-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWIND=2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWTRA-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWAGF-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWOTH-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/
     1  'GWTOT-2050ALLFLEX FLEX-H2GW H2GW H2TWH FRACH2 ',5(0PF12.5),/)
C
      WRITE(IOUT,171) FRCFLEXRES*PCT, FRCFLEXCOM*PCT, FRCFLEXIND*PCT,
     1                FRCFLEXTRA*PCT, FRCFLEXAGF*PCT, FRCFLEXOTH*PCT,
     1                FRCFLEXALL*PCT
 171  FORMAT('FRCFLEXRES% FRCFLEXCOM FRCFLEXIND FRCFLEXTRA FRCFLEXAGF ',
     1       'FRCFLEXOTH FRCFLEXALL '/,7(0PF11.5)/)
C
C ***************************************************************************
C            SET CHARGING/DISCHARGING RATES FOR NON-UTES STORAGE
C ***************************************************************************
C TSTORAIRC  = AVG ANNUAL LOAD (TW) FOR AIR COOLING (TW) SUBJECT TO STORAGE
C TSTORREFR  = AVG ANNUAL LOAD (TW) FOR REFRIGERATION SUBJECT TO STORAGE
C TSTORAWH   = AVG ANNUAL LOAD FOR AIR+WATER HEATING (TW) FROM STORAGE
C              (HOT WATER OR SOIL)
C TSTORPHS   = MAX DISCHARGE & CHARGE RATE PUMPED HYDRO STORAGE (TW)
C            = 57.683 GW 2010 U.S.
C            = 21.5 GW CURRENT PLUS PENDING LICENSES AS OF 10/1/14
C            + 34.033 MW PRELIMINARY PERMITS ISSUED + 2.15 MW PENDING PERMITS
C              http://www.ferc.gov/industries/hydropower/gen-info/licensing/
C              pump-storage.asp
C
C              2012 PHS WORLDWIDE 132.36 GW (EIA INTERNATIONAL ENERGY STATS)
C              (JAPAN 26.744 GW; US 22.368 GW; JAPAN; CHINA 21 GW)
C            http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=7
C TGWUTILPV  = NEW+EXISTING INSTALLED GW OF UTILITY-SCALE PV
C STORCTWH   = MAX NUMBER OF TWH OF CSP STORAGE
C TEXISTPHS  = CURRENT-YEAR PUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (TW)
C TEXISTSTH  = CURRENT-YEAR SOLAR THERMAL FOR HEAT NAMEPLATE CAPACITY (TW)
C EXISTPHSR  = PRE-EXISTING PUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (GW)
C              IN GRID REGION J=1,NUMGRIDS
C EXISOLTHR  = PRE-EXISTING SOLAR THERMAL FOR HEAT NAMEPLATE CAPACITY (GW)
C              IN GRID REGION J=1,NUMGRIDS
C TWPERGW    = 0.001    TERAWATTS (TW) PER GIGAWATT (GW)
C PHSMIN     = MIN PHS NAMEPLATE CAPAC (TW) IN 2050.
C              SOME REGIONS (E.G., JAMAICA, HAITI) NEED SMALL VALUES
C EGWHYD     = CURYEAR-YEAR INSTALLED GW OF HYDROELECTRIC POWER IN REGION
C
C FOR NON-US COUNTRIES ONLY:
C  MULTIPLY EXISTPHSR BY THE PROJECTED RATIO OF US PENDING+EXISTING/EXISTING
C  AND ADD CONSTANT SINCE SOME REGIONS HAVE NO INSTALLATIONS TO DATE
C
      IF (IFCONUS.EQ.1) THEN
       TEXISTSTH = 0.
       TEXISTPHS = 0.022368
       TSTORPHS  = 0.057683
      ELSEIF (IFSTATES.EQ.1.OR.IFCANARY.EQ.1) THEN
       TEXISTSTH = EXISOLTHR(IGRIDUSE) * TWPERGW
       TEXISTPHS = EXISTPHSR(IGRIDUSE) * TWPERGW
       TSTORPHS  = MAX(TEXISTPHS,PHSMIN)
      ELSE
       TEXISTSTH = EXISOLTHR(IGRIDUSE) * TWPERGW
       TEXISTPHS = EXISTPHSR(IGRIDUSE) * TWPERGW
       TSTORPHS  = 3.5 * TEXISTPHS  +  PHSMIN
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      ENDIF
C
C CSPSTORGAT = RATIO OF MAX CHARGE RATE (TW) OF CSP DIRECTLY-USED+STORED
C              ELECTRICITY TO DISCHARGE RATE (CSPDISCH) OF CSP GENERATORS.
C              THE NUMBER/SIZE OF MIRRORS IS ASSOCIATED WITH THE CHARGE RATE OF
C              STORAGE+DIRECT ELECTRICITY. GENERATOR SIZE ASSOC W/DISCHARGE RATE.
C            = 1->NO STORAGE.ALL CSP FOR ELEC AT CHARGE/DISCHARGE RATE CSPDISCH
C            = 2.6 --> TOTAL ELECTRICITY COLLECTION AT RATE 2.6 X CSPDISCH,
C              WHERE 1.6 X CSPDISCH FOR STORAGE & 1.0 X CSPDISCH FOR DIRECT ELEC
C              CSPSTORGAT MUST EQUAL CSPSTORG IN reader.f IN GATOR-GCMOM
C              FOR U.S. STATES OR 143 COUNTRIES, USE VALUE IN xlsx-spreadsheets
C              AT web.stanford.edu/group/efmh/jacobson/Articles/I/
C              WWS-50-USState-plans.html 'Tables for GATOR-GCMOM' TAB CELL A7
C CSPCHSTO   = MAX CHARGE RATE (TW) OF CSP STORAGE ONLY (NOT STORAGE +
C              DIRECT ELECTRICITY FROM TURBINES)  WHEN STORAGE EXISTS.
C            = CSPCHARG - CSPDISCH
C              IF NO CSP STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C CSPCHARG   = MAX CHARGE RATE (TW) OF CSP DIRECT ELECTRICITY + STORAGE
C            = CSPDISCH + CSPCHSTO
C              IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C              BASED ON SIZE OF MIRRORS (NOT SIZE OF GENERATOR)
C              CSP SOLAR COLLECTOR FIELD ARE OVERSIZED BY A FACTOR OF 3-5
C              COMPARED WITH THE SIZE NEEDED TO FEED THE STEAM TURBINE AT
C              NOMINAL DESIGN CAPACITY WITH MAX SOLAR IRRADIANCE (1 KW/M2)
C              http://www.irena.org/DocumentDownloads/Publications/IRENA-
C              ETSAP%20Tech%20Brief%20E10%20Concentrating%20Solar%20Power.pdf
C              PAGE 5
C CSPDISCH   = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C            = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C              IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C
      CSPCHSTO  = CSPDISCH * (CSPSTORGAT - 1.)
      CSPCHARG  = CSPDISCH + CSPCHSTO
C
C RATIOCSP  = RATIO OF TW OF CSP COLLECED IN MIRRORS FOR DIRECT ELECTRICITY
C             USE PLUS STORAGE TO THAT USED TO DERIVE OUTPUT IN GATOR-GCMOM (KWWS)
C             (WHICH IS BASED ONLY ON DISCHARGE RATE)
C           = CSPCHARG / TWCSPGAT
C CSPCHARG  = MAX CHARGE RATE (TW) OF CSP DIRECT ELECTRICITY + STORAGE
C           = CSPDISCH + CSPCHSTO
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C             BASED ON SIZE OF MIRRORS (NOT SIZE OF GENERATOR)
C             CSP SOLAR COLLECTOR FIELD ARE OVERSIZED BY A FACTOR OF 3-5
C             COMPARED WITH THE SIZE NEEDED TO FEED THE STEAM TURBINE AT
C             NOMINAL DESIGN CAPACITY WITH MAX SOLAR IRRADIANCE (1 KW/M2)
C             http://www.irena.org/DocumentDownloads/Publications/IRENA-
C             ETSAP%20Tech%20Brief%20E10%20Concentrating%20Solar%20Power.pdf
C             PAGE 5
C TWCSPGAT  = TW ALL CSP INSTALLED WORLDWIDE IN GATOR-GCMOM
C TGWSHEAT  = NEW+EXISTING INSTALLED GW OF SOLAR HOT WAT/GLYCOL COLLECTORS
C AGWSHEAT  = NEW INSTALLED GW SOLAR THERM HOT WAT/GLYCOL SOLN COLLECTORS
C             FOR COST PURPOSES (SINCE COST/MW ASSUMED SAME AS UTILITY PV)
C             ENERGY OUTPUT FROM SOLAR HEAT
C
      IF (TWCSPGAT.GT.SMAL30) THEN
       RATIOCSP   = CSPCHARG / TWCSPGAT
      ELSE
       RATIOCSP   = 0.
      ENDIF
C
      WRITE(IOUT,148) RATONSHW,  RATOFFSHW, RATROOFPV,
     1                RATUTILPV, RATIOCSP,  RATSHEAT,
     1                TWONSHGAT, TWOFFSHGAT,TWROOFPVG,
     1                TWUTILPVG, TWCSPGAT,  TWSHTGAT
 148  FORMAT('RATONSHW  RATOFFSHW  RATROOFPV = ',3(0PF12.4),/
     1       'RATUTILPV RATIOCSP   RATSHEAT  = ',3(0PF12.4),/
     1       'TWONSHGAT TWOFFSHGAT TWROOFPVG = ',3(0PF12.4),/
     1       'TWUTILPVG TWCSPGAT   TWSHTGAT  = ',3(0PF12.4),/)
C
C TGWSHEAT = NEW+EXISTING INSTALLED GW OF SOLAR HOT WAT/GLYCOL COLLECTORS
C TGWGEOHT = NEW+EXISTING INSTALLED GW OF GEOTHERMAL HEAT
C TWPERGW  = 0.001 TERAWATTS (TW) PER GIGAWATT (GW)
C TWINUTES = MAX CHARGE RATE (TW) OF UTES STORAGE FROM SOLAR THERMAL COLLECTORS
C          + GEOTHERMAL HEAT
C            SET EQUAL TO NAMEPLATE CAPACITY OF SOLAR THERMAL +
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C             GEOTHERMAL HEAT COLLECTORS DIVIDED BY COP OF HEAT PUMPS (CPERFORM)
C             SINCE SUPPLY OF HEAT ALSO CONVERTED TO EQUIVALENT ELECTRICITY
C             NEEDED TO SUPPLY HEAT FROM ELECTRIC HEAT PUMPS
C             NOT DIVIDED BY CPERFORM SINCE SOLAR+GEOTHERMAL HEAT
C             ARE SUPPLYING WWS HEAT IN IEA DATABASE DIRECTLY, AND WWS
C             HEAT IS INCLUDED 1:1 AS HEAT IN IEA DATABASE
C CPERFORM = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C             (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C           = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
C           = 1 FOR ELECTRIC RESISTANCE HEATING
C           = 3.2-4.5 FOR AIR SOURCE HEAT PUMPS
C           = 4.2-5.2 FOR GROUND SOURCE HEAT PUMPS
C CPERF1   = CPERFORM = COEF OF PERFORMANCE OF HEAT PUMPS WHEN NEW SOLAR+GEOTHERMAL
C             HEAT ASSUMED. NEW SOLAR+GEOTHERMAL HEAT ARE ASSUMED TO BE
C             CONVERTED TO ELECTRICITY POWERING HEAT PUMPS
C           = 1 WHEN ONLY EXISTING SOLAR+GEOTHERMAL HEAT ASSUMED SINCE EXISTING
C             SOLAR+GEOTHERMAL HEAT IS TREATED AS DIRECT HEAT IN IEA DATABASE
C             SO NO NEED TO CONVERT TO EQUIVALENT ELECTRICITY
C
      IF (STORUGDYS.GT.0.) THEN
       TWINUTES = (TGWSHEAT + TGWGEOHT) * TWPERGW / CPERF1
      ELSE
       TWINUTES = 0.
      ENDIF
C
C STORCTWH  = MAX STORAGE CAPACITY (TWH) OF CSP STORAGE
C STORPTWH  = MAX STORAGE CAPACITY (TWH) OF PHS STORAGE
C STOROTWH  = MAX STORAGE CAPACITY (TWH) OF CW-STES + PCM-ICE STORAGE
C STORBTWH  = MAX STORAGE CAPACITY (TWH) OF BATTERY STORAGE
C STOHBTWH  = MAX STORAGE CAPACITY (TWH-THERMAL) OF BRICK HEAT BATTERY STORAGE
C STORFTWH  = MAX STORAGE CAPACITY (TWH) OF ENERGY TO MAKE H2 FOR GRID ELEC STORAGE
C           = ENERGY IN ELECTRICITY USED TO PRODUCE/COMPRESS HYDROGEN
C             MULT STORFTWH BY H2CHAREFF TO GET MAX ENERGY IN H2 IN STORAGE
C           = MAX H2 IN STORAGE (TG-H2) * H2ENERGY (KWH/KG-H2)
C           = MAX ENERGY FROM FUEL CELL (TWH) / (H2DCEFF*H2CHAREFF)
C           = FCDISCH (TW) * STORHHFC (HOURS) / (H2DCEFF*H2CHAREFF)
C           = H2SDISCH TW) * STORHHFC(HOURS)
C           = 0 WHEN IMERGH2 = 1,3 OR 0
C STORHTWH  = MAX STORAGE CAPACITY (TWH) OF HW-STES STORAGE
C STORWTWH  = MAX STORAGE CAPACITY (TWH) OF CW-STES STORAGE
C STORITWH  = MAX STORAGE CAPACITY (TWH) OF PCM-ICE STORAGE
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C           = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C CSPCHSTO  = MAX CHARGE RATE (TW) OF CSP STORAGE ONLY (NOT STORAGE +
C             DIRECT ELECTRICITY FROM TURBINES)  WHEN STORAGE EXISTS.
C           = CSPCHARG - CSPDISCH
C             IF NO CSP STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C TSTORPHS  = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C TSTORCOOL = AVG ANNUAL ELEC LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C HBTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW-TH) OF HEAT BATTERIES
C FCCHARG   = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C H2SDISCH  = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             ASSUMES GRID H2 STORAGE ENERGY IS ENERGY USED TO
C             PRODUCE AND COMPRESS H2 = ENERGY EMBODIED IN H2 / H2CHAREFF
C           = FCDISCH (TW) / (H2DCEFF * H2CHAREFF)
C HOTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF HW-STES
C             REALLY MAX DISCHARGE AND CHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
C CHILDISCH = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C HCHARCSP  = MAX NUMBER HOURS THAT CSP CAN BE CHARGED FOR AT RATE CSPCHSTO
C             TO REACH FULL CAPACITY OF STORCTWH
C STORHPHS  = MAX HOURS PUMPED HYDRO STORAGE (PHS)
C STORHCOLD = MAX HOURS PHASE-CHANGE MATERIAL (PCM)-ICE AND
C             CHILLED-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE (CW STES)
C STORHBAT  = MAX HOURS BATTERY STORAGE AT MAX DISCHARGE RATE
C             USE TESLA POWERWALL EXAMPLE: 6.4 KWH, 3.3 KW MAX CHARGE/DISCHARGE
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C             --> 1.94 HOURS STORAGE AT MAX DISCHARGE RATE
C STORHHFC  = MAX HOURS H2 ELECTRICITY STORAGE AT MAX DISCHARGE RATE
C           = 0 WHEN IMERGH2 = 1,3, OR 0. APPLIES ONLY WHEN IMERGH2 = 2.
C STORHHWAT = MAX HOURS HOT-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE
C
C IT IS CORRECT TO USE CSPCHSTO INSTEAD OF CSPDISCH HERE
C
      STORCTWH  = CSPCHSTO  * HCHARCSP
      STORPTWH  = TSTORPHS  * STORHPHS
      STOROTWH  = TSTORCOOL * STORHCOLD
      STORBTWH  = BATDISCH  * STORHBAT
      STOHBTWH  = HBTDISCH  * STORHHBT
      STORFTWH  = H2SDISCH  * STORHHFC
      STORHTWH  = HOTDISCH  * STORHHWAT
C
C THESE TWO SUM UP TO STOROTWH
C
      STORWTWH  = CHILDISCH * STORHCOLD
      STORITWH  = PCMDISCH  * STORHCOLD
C
C STORHCSP  = HOURS OF CSP STORAGE (HOURS TO DISCHARGE CSP STORAGE AT RATE
C             CSPDISCH WHEN STORAGE AT FULL CAPACITY)
C
      STORHCSP = STORCTWH / (CSPDISCH + SMAL30)
C
C STORTWH = MAX STORAGE CAPACITY (TWH) OF NON-UTES, NON-H2 STORAGE,
C           EXCEPT, IT INCLUDES H2 STORAGE FOR GRID ELECTRICITY
C CHARGTW = MAX RATE OF CHARGING (TW)  OF NON-UTES, NON-H2 STORAGE
C           EXCEPT, IT INCLUDES H2 STORAGE FOR GRID ELECTRICITY
C           THIS IS GREATER THAN RATE OF DISCHARGING SINCE CSP COLLECTORS
C           ARE OVERSIZED RELATIVE TO STEAM TURBINE.
C           ALSO, MAX CHARGE & DISCHARGE RATES OF H2 FOR ELEC STORAGE DIFFER
C           CHARGING AND DISCHARGING RATES ARE THE SAME FOR OTHERS.
C DISCHTW = DISCHARGE RATE ALL NON-UTES, NON-H2 STORAGE (TW, EXCEPT
C           INCLUDES H2 STORAGE FOR GRID ELECTRICITY
C
      STORTWH   = STORCTWH + STORPTWH + STOROTWH  + STORBTWH + STORFTWH
     1          + STORHTWH + STOHBTWH
      CHARGTW   = CSPCHSTO + TSTORPHS + TSTORCOOL + BATDISCH + FCCHARG
     1          + HOTCHARG + HBTCHARG
      DISCHTW   = CSPDISCH + TSTORPHS + TSTORCOOL + BATDISCH + H2SDISCH
     1          + HOTDISCH + HBTDISCH
C
C STORHOURS = AVG NUMBER OF HOURS OF STORAGE AMONG ALL NON-UTES, NON-H2 STORAGE
C             EXCEPT, IT INCLUDES H2 STORAGE FOR GRID ELECTRICITY
C
      STORHOURS = STORTWH / DISCHTW
C
C UTESTWH   = MAX STORAGE CAPACITY (TWH) UNDERGROUND SEAS HEAT STORAGE IN SOIL
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C STORUGHRS = HOURS OF UNDERGROUND SEASONAL HEAT STORAGE (UTES) (HRS)
C
      UTESTWH   = UTESDISCH * STORUGHRS
C
C FEXISTPHS = FRACTION OF PROPOSED PHS STORAGE THAT ALREADY EXISTS
C TEXISTPHS = EXISTING PUMPED-HYDRO STORAGE (PHS) INSTALLED CAPACITY (TW)
C
      FEXISTPHS = TEXISTPHS / TSTORPHS
C
C FRACCSP   = FRAC OF KWH OF NON-UTES STORAGE IN PHASE-CHANGE MATERIAL FROM CSP
C FRACPHS   = FRAC OF KWH OF NON-UTES STORAGE IN PUMPED-HYDRO STORAGE
C FRACOLD   = FRAC OF KWH OF NON-UTES STORAGE IN COLD-WATER (CW)-STES
C FRACPCM   = FRAC OF KWH OF NON-UTES STORAGE IN PCM (ICE)
C FRACHOT   = FRAC OF KWH OF NON-UTES STORAGE IN HOT-WATER STES
C FRACBAT   = FRAC OF KWH OF NON-UTES STORAGE THAT IS L-I BATTERIES
C FRACHBT   = FRAC OF KWH OF NON-UTES STORAGE THAT IS FOR HEAT BATTERIES
C FRACHFC   = FRAC OF KWH OF NON-UTES STORAGE THAT IS H2 STORAGE FOR ELECTRIDITY
C HCHARCSP  = MAX NUMBER HOURS THAT CSP CAN BE CHARGED FOR AT RATE CSPCHSTO
C             TO REACH FULL CAPACITY OF STORCTWH
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C STORHCSP  = HOURS OF CSP STORAGE (HOURS TO DISCHARGE CSP STORAGE AT RATE
C             CSPDISCH WHEN STORAGE AT FULL CAPACITY)
C STORHPHS  = MAX HOURS PUMPED HYDRO STORAGE (PHS)
C STORHCOLD = MAX HOURS PHASE-CHANGE MATERIAL (PCM)-ICE AND
C             CHILLED-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE (CW STES)
C STORHHWAT = MAX HOURS HOT-WATER SENSIBLE-HEAT THERMAL ENERGY STORAGE
C STORHBAT  = MAX HOURS BATTERY STORAGE AT MAX DISCHARGE RATE
C STORHHFC  = MAX HOURS H2 ELECTRICITY STORAGE AT MAX DISCHARGE RATE
C STORUGHRS = HOURS OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL (UTES) (HRS)
C CSPCHSTO  = MAX CHARGE RATE (TW) OF CSP STORAGE ONLY (NOT STORAGE +
C             DIRECT ELECTRICITY FROM TURBINES)  WHEN STORAGE EXISTS.
C           = CSPCHARG - CSPDISCH
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C TSTORPHS  = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C CHILDISCH = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C TSTORPHS  = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C HOTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF HW-STES
C             REALLY MAX DISCHARGE AND CHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C H2SDISCH  = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             ASSUMES GRID H2 STORAGE ENERGY IS ENERGY USED TO
C             PRODUCE AND COMPRESS H2 = ENERGY EMBODIED IN H2 / H2CHAREFF
C           = FCDISCH (TW) / (H2DCEFF * H2CHAREFF)
C
      FRACCSP  = CSPCHSTO  * HCHARCSP  / STORTWH
      FRACPHS  = TSTORPHS  * STORHPHS  / STORTWH
      FRACOLD  = CHILDISCH * STORHCOLD / STORTWH
      FRACPCM  = PCMDISCH  * STORHCOLD / STORTWH
      FRACHOT  = HOTDISCH  * STORHHWAT / STORTWH
      FRACBAT  = BATDISCH  * STORHBAT  / STORTWH
      FRACHFC  = H2SDISCH  * STORHHFC  / STORTWH
      FRACHBT  = HBTDISCH  * STORHHBT  / STORTWH
C
      SUMFRAC  = FRACCSP + FRACPHS + FRACOLD + FRACPCM
     1         + FRACHOT + FRACBAT + FRACHFC + FRACHBT
C
C TSTORAIRC  = AVG ANNUAL LOAD (TW) FOR AIR COOLING (TW) SUBJECT TO STORAGE
C TSTORREFR  = AVG ANNUAL LOAD (TW) FOR REFRIGERATION SUBJECT TO STORAGE
C TSTORCOOL  = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C            = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C CHILDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH   = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C FRSTORINIT = FRACTION (0-1) OF MAX STORAGE CAPACITY THAT THE STORAGE MEDIUM
C              HAS IN STORAGE AT THE BEGINNING OF THE SIMULATION. APPLIES TO
C              ALL STORAGE EXCEPT FOR HYDROPOWER, WHICH IS ASSUMED FULL AT START
C
      WRITE(IOUT,179)
     1  TSTORCOOL*1E3, TSTORAIRC*1E3, TSTORREFR*1E3,
     1  TSTORCOOL*1E3, CHILDISCH*1E3, PCMDISCH *1E3,
     1  TSTORPHS *1E3, PHSMIN   *1E3, TEXISTPHS*1E3,
     1  HCDDADD,       FRSTORINIT, HDISSIP, FRCIHFLEX
C
 179  FORMAT('TSTORCOOL(GW)               = ',0PF13.6,/
     1       'TSTORAIRC(GW)               = ',0PF13.6,/
     1       'TSTORREFR(GW)               = ',0PF13.6,/
     1       'CHARGE-RATE STES+PCM (GW)   = ',0PF13.6,/
     1       'CHARGE-RATE STES (GW)       = ',0PF13.6,/
     1       'CHARGE-RATE PCM (GW)        = ',0PF13.6,/
     1       'TSTORPHS,PHSMIN,TEXISTPHS-GW = ',3(0PF13.6,1X)/
     1       'HCDDADD (HDD & CDD DAYS)    = ',0PF13.6,/
     1       'FRSTORINIT HDISSIP FRCIHFLEX = ',3(0PF13.6,1X)/)
C
C STORCINIT = INITIAL ENERGY AVAILABLE IN CSP STORAGE (TWH)
C STORCCUR  = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C
      STORCINIT = FRSTORINIT * STORCTWH
      STORCCUR  = STORCINIT
      TREMCSTOR = 0.
C
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C STORPINIT = INITIAL ENERGY AVAILABLE IN PHS STORAGE (TWH)
C STORPCUR  = CURRENT ENERGY AVAILABLE IN PHS STORAGE (TWH)
C
      STORPINIT = FRSTORINIT * STORPTWH
      STORPCUR  = STORPINIT
      TREMPSTOR = 0.
C
C STOROINIT = INITIAL ENERGY AVAILABLE IN CW-STES + PCM-ICE STORAGE (TWH)
C STOROCUR  = CURRENT ENERGY AVAILABLE IN CW-STES + PCM-ICE STORAGE (TWH)
C
      STOROINIT = FRSTORINIT * STOROTWH
      STOROCUR  = STOROINIT
      TREMOSTOR = 0.
C
C STORHINIT = INITIAL ENERGY AVAILABLE IN HW-STES STORAGE (TWH)
C STORHCUR  = CURRENT ENERGY AVAILABLE IN HW-STES STORAGE (TWH)
C
      STORHINIT = FRSTORINIT * STORHTWH
      STORHCUR  = STORHINIT
      TREMHSTOR = 0.
C
C STORBINIT = INITIAL ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C STORBCUR  = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C
      STORBINIT = FRSTORINIT * STORBTWH
      STORBCUR  = STORBINIT
      TREMBSTOR = 0.
      TDISCHBAT = 0.
C
C STORFINIT = INITIAL ENERGY AVAILABLE IN H2 STORAGE FOR ELECTRICITY (TWH)
C STORFCUR  = CURRENT ENERGY AVAILABLE IN H2 STORAGE FOR GRID ELECTRICITY (TWH)
C H2GRTANK  = MAX STORAGE (TG-H2) THAT H2 TANKS FOR GRID H2 CAN HOLD AT GIVEN TIME
C STORFTWH  = MAX STORAGE CAPACITY (TWH) OF ENERGY TO MAKE H2 FOR GRID ELEC STORAGE
C           = ENERGY IN ELECTRICITY USED TO PRODUCE/COMPRESS HYDROGEN
C             MULT STORFTWH BY H2CHAREFF TO GET MAX ENERGY IN H2 IN STORAGE
C           = MAX H2 IN STORAGE (TG-H2) * H2ENERGY (KWH/KG-H2)
C           = MAX ENERGY FROM FUEL CELL (TWH) / (H2DCEFF*H2CHAREFF)
C           = FCDISCH (TW) * STORHHFC (HOURS) / (H2DCEFF*H2CHAREFF)
C           = H2SDISCH TW) * STORHHFC(HOURS)
C           = 0 WHEN IMERGH2 = 1,3 OR 0
C H2ENERGY  = TWH/TG-H2-PRODUCED-AND-COMPRESSED (=KWH/KG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C
      H2GRTANK  = STORFTWH / H2ENERGY
      STORFINIT = FRSTORINIT * STORFTWH
      STORFCUR  = STORFINIT
      TREMFSTOR = 0.
      TDISCHHFC = 0.
C
C UGSTINIT  = INITIAL ENERGY AVAILABLE IN UNDERGROUND UTES STORAGE (TWH)
C             REALLY EQUIVALENT ELECTRICITY THAT GIVES NEEDED HEAT
C             WITH HEAT PUMPS OF COP=CPERFORM
C UGSTORCUR = CURRENT ENERGY IN UNDERGROUND SOIL OR WATER STORAGE (TWH)
C             REALLY CURRENT TWH OF ELECTRICITY STORED IN UTES THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C
      UGSTINIT   = FRSTORINIT * UTESTWH
      UGSTORCUR  = UGSTINIT
      TREMUSTOR  = 0.
C
C BRICKINIT = INITIAL ENERGY AVAILABLE IN BRICK IND HEAT STORAGE (TWH)
C BRSTORCUR = CURRENT ENERGY IN BRICK IND HEAT STORAGE (TWH)
C STOHBTWH  = MAX STORAGE CAPACITY (TWH-THERMAL) OF BRICK HEAT BATTERY STORAGE
C
      BRICKINIT  = FRSTORINIT * STOHBTWH
      BRSTORCUR  = BRICKINIT
      TBRICKTWH  = 0.
C
C H2STINIT  = INITIAL STORED H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE/H2)
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C           = TOTAL TWH OF H2 THAT CAN BE PUT IN STORAGE. DAYH2STOR CHANGES VALUE.
C H2CURSTOR = CUR STORED H2 (TWH-ELECTRICITY USED TO PRODUCE/COMPRESS/STORE H2)
C
      H2STINIT  = 0.9 * H2STORMX
C      h2stinit  = 0.9 * twhh2tot*10./dayspy
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      H2CURSTOR = H2STINIT
C
C ***************************************************************************
C                      CALCULATE HYDROPOWER PARAMETERS
C                HYDROPOWER IS USED FOR BOTH BASELOAD AND PEAKING
C ***************************************************************************
C
C DISHPINIT = INIT DISCHARGE RATE HYDROPOWER (TW) BASED ON INSTALLED CAPACITY
C TGWHYD    = NEW+EXISTING INSTALLED GW OF HYDRPOWER OVER REGION IGRIDUSE
C             BEFORE ADDED TURBINES
C TWPERGW   = 0.001    TERAWATTS (TW) PER GIGAWATT (GW)
C TWPERMW   = 0.000001 TERAWATTS (TW) PER MEGAWATT (MW)
C HPTURBRAT = RATIO OF NEEDED DISCHARGE RATE (TW) OF HYDROPOWER
C              TO 2050 INSTALLED DISCHARGE RATE (TW). ADDITIONAL DISCHARGE
C              OBTAINED BY ADDING TURBINES/GENERATORS/TRANSFORMERS WITHOUT
C              INCREASING SIZE OF DAM (HOLDING ANNUAL ENERGY OUTPUT CONSTANT)
C HYDISCHTW = MAX TOTAL DISCHARGE RATE OF HYDROELECTRIC POWER (TW)
C             USED FOR BOTH BASELOAD AND PEAKING
C           = INITIAL NAMEPLATE CAPACITY (DISHPINIT) * HPTURBRAT
C
      DISHPINIT = TGWHYD * TWPERGW
      HYDISCHTW = DISHPINIT *  HPTURBRAT
C
C HYDTWHMAX = MAX TWH ENERGY THAT CAN BE STORED IN ALL HYDRO RESERVOIRS
C             FOR PEAKING+BASELOAD FROM HYDRO TURBINE BEF T&D IN REGION AT GIVEN MOMENT
C             NOTE. ENERGY BEYOND HYDTWHMAX ALSO EXISTS IN WATER IN
C             RESERVOIR, BUT IT IS NOT USED. ONLY ~50-60% OF WATER IN
C             RESERVOIR CAN BE USED FOR ENERGY (IEA 2021 SPECIAL MARKET REPORT P.95)
C             NOTE2. BECAUSE DAMCAPRAT IS DERIVED FROM CURHYD, MULTIPLY
C             DAMCAPRAT BY CURHYD (NOT TURBHYD) TO OBTAIN DAM CAPACITY.
C DAYBASHYD = DAYS OF BASELOAD HYDROPOWER STORAGE AT BASEHYD PEAK DISCHARGE RATE
C             DEFAULT = 60 DAYS. DECREASE TO <60 FOR MORE STORAGE FOR PEAKING
C             AS DAYBASHYD->0      ->BASHYDMX->0        ->ALL STORAGE FOR PEAKING
C             AS DAYBASHYD->HREFILL->BASHYDMX->HYDTWHMAX->ALL STORAGE FOR BASE
C HBASHY    = HOURS BASELOAD HYDRO STORED IN RESERVOIRS (BASHYDMX) WHEN
C             DISCHARGED AT PEAK DISCH RATE (BASHYD) OR CHARGED AT PEAK
C             CHARGE RATE (BASHYD)
C             BASELOAD HYDRO IS CONTINUOUSLY PRODUCED FROM RUNOFF AND
C             RELEASED, SO REALLY DOESN'T NEED STORAGE. HOWEVER, BECAUSE
C             IN REALITY, HYDRO NOT PRODUCED CONTINUOUSLY, ALLOW FOR
C             HBASHY HOURS OF STORAGE THAT CAN'T BE USED FOR PEAKING
C           = BASHYDMX / BASHYD
C           = 60 DAYS X 24 HR/DAY BY DEFAULT
C             EXCEPT LOCS WITH LOW STORAGE, THEN=HREFILL.
C             USE HREFILL AND NOT DAMCAPRAT*AVHRSPYR=HYDTWHMAX/CURHYD
C             SINCE DAMS ARE FILLED AT RATE TURBHYD, NOT CURHYD.
C             AS HBASHY->0      ->BASHYDMX->0        ->ALL STORAGE FOR PEAKING
C             AS HBASHY->HREFILL->BASHYDMX->HYDTWHMAX->ALL STORAGE FOR BASE
C HPEAKH    = HOURS NEEDED TO REFILL PEAKING HYDRO STORAGE (PKHYDMAX) AT
C             CHARGE RATE PEAKHYD.
C           = PKHYDMAX / PEAKHYD
C             WHEN HPEAKH=8760, THEN STORAGE FOR PEAKING FILLED ONCE PER YEAR
C             HPEAKH MUST BE A MINIMUM OF HREFILL = HYDTWHMAX/TURBHYD.
C             WHEN HPEAKH=HREFILL, ALL STORAGE IS FOR PEAKING NONE IS FOR BASELOAD
C             THE LARGER HPEAK, THE MORE STORAGE=BASELOAD FOR GIVEN HBASHY
C HREFILL   = HOURS TO REFILL ALL HYDRO (PEAK + BASELOAD) IF RECHARGED AT RATE TURBHYD
C DAMCAPRAT = RATIO OF HYDRO DAM ENERGY STORAGE CAPACITY TO ANNUAL
C             HYDRO ENERGY OUTPUT FOR REGION (TWH/TWH/Y = UNITS OF YEARS)
C             THIS IS THE FRACTION OF A YEAR THAT A HYDRO PLANT CAN
C             DISCHARGE AT ITS PEAK DISCHARGE RATE
C CURHYD    = 2050 ANNUAL AVG BASE+PEAK HYDRO DELIVERED POWER AFTER T&D LOSSES (TW)
C TURBHYD   = 2050 ANNUAL AVG BASE+PEAK HYDRO RELEASED FROM TURBINE (TW) BEF T&D LOSSES
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR BASELOAD+PEAKING (TW) BEF T&D
C BASEHYD   = 2050 HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR BASELOAD POWER (TW)
C           = CONSTANT CHARGE AND DISCHARGE RATE (TW) OF HYDRO FOR BASELOAD
C PEAKHYD   = 2050 ANN-AVG HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR PEAKING POWER (TW)
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR PEAKING (TW) BEF T&D
C             BASEHYD, PEAKHYD, AND TURBHYD ARE ALL BEFORE T&D LOSSES
C AVHRSPYR  = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C
      HYDTWHMAX = DAMCAPRAT * CURHYD * AVHRSPYR
      TURBHYD   = CURHYD / TDEFFMN(IHYDRO)
      IF (TURBHYD.GT.0.) THEN
       HREFILL  = HYDTWHMAX / TURBHYD
      ELSE
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       HREFILL  = 0.
      ENDIF
C
      HBASHY    = MAX(MIN(DAYBASHYD*HRSPDAY,HREFILL),0.001)
      HPEAKH    = MAX(AVHRSPYR,HREFILL)
C
C CURHYD    = 2050 REGIONAL BASE+PEAK HYDRO DELIVERED POWER AFTER T&D LOSSES (TW)
C TURBHYD   = 2050 ANNUAL AVG BASE+PEAK HYDRO RELEASED FROM TURBINE (TW) BEF T&D LOSSES
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR BASELOAD+PEAKING (TW) BEF T&D
C BASEHYD   = 2050 HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR BASELOAD POWER (TW)
C           = CONSTANT CHARGE AND DISCHARGE RATE (TW) OF HYDRO FOR BASELOAD
C PEAKHYD   = 2050 ANN-AVG HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR PEAKING POWER (TW)
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR PEAKING (TW) BEF T&D
C             BASEHYD, PEAKHYD, AND TURBHYD ARE ALL BEFORE T&D LOSSES
C PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
C           = HYDISCHTW - BASEHYD
C HYDISCHTW = MAX TOTAL DISCHARGE RATE OF HYDROELECTRIC POWER (TW)
C             USED FOR BOTH BASELOAD AND PEAKING
C           = INITIAL NAMEPLATE CAPACITY (DISHPINIT) * HPTURBRAT
C PKHYDMAX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR PEAKING BEF T&D ACCOUNTED FOR
C BASHYDMX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR BASELOAD BEF T&D ACCOUNTED FOR
C TDEFFMN   = 1-TDLOSMN = TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C
C            MAX CHARGE(TW)    MAX DISCHARGE(TW)   DAM CAPACITY (TWH)
C TOTAL        TURBHYD (Ct)       HYDISCHTW (Nt)    HYDTWHMAX (St)
C BASELOAD     BASEHYD (Cb)       BASEHYD   (Nb)    BASHYDMX  (Sb)
C PEAKING      PEAKHYD (Cp)       PKHYDISCH (Np)    PKHYDMAX  (Sp)

C SOLVE 5 EQS, 5   UNKNOWNS (BASHYD PEAKHYD PKHYDISCH BASHYDMX PKHYDMAX)
C              3   KNOWNS (TURBHYD,HYDISCHTW,HYDTWHMAX)
C
C                 BASEHYD  + PEAKHYD   = TURBHYD
C                 BASEHYD  + PKHYDISCH = HYDISCHTW
C                 BASHYDMX + PKHYDMAX  = HYDTWHMAX
C                 BASEHYD * HBASHY     = BASHYDMX
C                 PEAKHYD * HPEAKH     = PKHYDMAX
C
C       --> BASEHYD + PKHYDMAX/HPEAKH = TURBHYD
C       --> BASHYDMX/HBASHY + (HYDTWHMAX-BASHYDMX)/HPEAKH = TURBHYD
C       --> (HPEAKH/HBASHY-1)*BASHYDMX + HYDTWHMAX = TURBHYD*HPEAKH
C       --> BASHYDMX = (TURBHYD*HPEAKH-HYDTWHMAX)/(HPEAKH/HBASHY-1)
C
C
      BASHYDMX  = (TURBHYD*HPEAKH-HYDTWHMAX)/(HPEAKH/HBASHY-1.)
      BASEHYD   = BASHYDMX / HBASHY
      PEAKHYD   = MAX(TURBHYD - BASEHYD,0.)
      PKHYDISCH = MAX(HYDISCHTW - BASEHYD,0.)
      PKHYDMAX  = MAX(HYDTWHMAX - BASHYDMX,0.)
C
C BASHAFT   = 2050 REGIONAL DELIVERED HYDRO FOR BASELOAD AFTER T&D LOSSES (TW)
C PKHAFT    = 2050 REGIONAL DELIVERED HYDRO FOR PEAKING AFTER T&D LOSSES (TW)
C
      BASHAFT   = BASEHYD * TDEFFMN(IHYDRO)
      PKHAFT    = PEAKHYD * TDEFFMN(IHYDRO)
C
C ADDHPDIS  = ADDED HYDROPOWER INSTALLED DISCHARGE CAPACITY (MW)
C             DUE TO ADDITIONAL TURBINES/GENERATORS/TRANSFORMERS
C             COST FROM IRENA (2012) RENEW ENERGY TECHS: COST ANAL FIG 4.7
C             http://www.irena.org/documentdownloads/publications/
C              re_technologies_cost_analysis-hydropower.pdf
C FELECHP   = FRACTION OF TOTAL CAPITAL COST OF HYDROPOWER THAT IS FOR
C             ELECTRICAL EQUIPMENT (TURBINES/GENERATORS/TRANSFORMERS
C             ~16% ($556/KW) 500 MW PLANT TOT COST $3,500 (FIG 4.5 IRENA 2012)
C             ($200-300/KW) 1000 MW PLANTS FIG. 4.7
C
      ADDHPDIS  = (HYDISCHTW - DISHPINIT) / TWPERMW
      FELECHP   = 0.16
C
C HYDROINIT = INIT HYDRO ENERGY (TWH) STORED IN RESERVOIRS FOR PEAKING RELEASED FROM TURBINE
C PKHYDMAX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR PEAKING BEF T&D ACCOUNTED FOR
C HYDROTWH  = CURRENT TWH OF AVAILABLE HYDROPOWER HELD IN RESERVOIRS IN REGION
C             FOR PEAKING POWER. MAX VALUE IS PKHYDMAX.  EACH TIME STEP, ADD
C             PEAKHYD*PERHRS TWH TO RESERVOIR. HYDRO SUBTRACTED AT RATE THAT VARIES
C             FROM 0 TO PKHYDISCH*PERHRS EACH TIME STEP. HYDROTWH DOES
C             NOT STORE HYDRO USED FOR BASELOAD. THAT IS STORED IN BASHYDMX
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C             HYDROTWH INCLUDES ENERGY BEFORE T&D LOSSES ACCOUNTED FOR
C
      HYDROINIT = 0.95 * PKHYDMAX
      HYDROTWH  = HYDROINIT
C
      CUMSHED   = 0.
C
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C UTESCHARG = MAX CHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             FROM EXCESS ELECTRIC POWER GENERATION
C             SINCE LOW-TEMP HEAT LOAD IN countrystats.dat ALREADY
C             CONVERTED TO EQUIVALENT ELECTRICAL LOAD ASSUMING
C             HEAT PUMPS WITH CPERFORM, UTESCCHARG IS REALLY THE CHARGE
C             RATE OF EQUIV ELECTRICITY TO GIVE HEATING FROM HEAT PUMPS
C UTESTWH   = TWH OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL OR WATER
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C TWHNONU   = MAX STARAGE CAPACITY (TWH) OF NON-UTES, NON-HW-STES, NON-H2 STORAGE
C FRACOOL   = FRAC OF NON-UTES, NON-HW-STES STORAGE THAT IS CW-STES OR PCM-ICE
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C CSPCHELC  = MAX CHARGE RATE (TW) OF CSP FOR DIRECTLY ELECTRICITY PRODUCTION
C           = THE REST OF CSP CHARGE GOES TO STORAGE.
C           = CSPCHARG - CSPCHSTO.
C CHARGTW   = MAX RATE OF CHARGING (TW)  OF NON-UTES, NON-H2 STORAGE
C             THIS IS GREATER THAN RATE OF DISCHARGING SINCE CSP COLLECTORS
C             ARE OVERSIZED RELATIVE TO STEAM TURBINE.
C             CHARGING AND DISCHARGING RATES ARE THE SAME FOR OTHERS.
C DISCHTW   = DISCHARGE RATE ALL NON-UTES, NON-H2 STORAGE (TW)
C HYDISCHTW  = MAX TOTAL DISCHARGE RATE OF HYDROELECTRIC POWER (TW)
C              USED FOR BOTH BASELOAD AND PEAKING
C HYDTWHMAX = MAX TWH ENERGY THAT CAN BE STORED IN ALL HYDRO RESERVOIRS
C             FOR PEAKING+BASELOAD FROM HYDRO TURBINE BEF T&D IN REGION AT GIVEN MOMENT
C PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
C           = HYDISCHTW - BASEHYD
C PKHYDMAX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR PEAKING BEF T&D ACCOUNTED FOR
C BASHYDMX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR BASELOAD BEF T&D ACCOUNTED FOR
C CURHYD    = 2050 REGIONAL BASE+PEAK HYDRO DELIVERED POWER AFTER T&D LOSSES (TW)
C TURBHYD   = 2050 ANNUAL AVG BASE+PEAK HYDRO RELEASED FROM TURBINE (TW) BEF T&D LOSSES
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR BASELOAD+PEAKING (TW) BEF T&D
C BASEHYD   = 2050 HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR BASELOAD POWER (TW)
C           = CONSTANT CHARGE AND DISCHARGE RATE (TW) OF HYDRO FOR BASELOAD
C PEAKHYD   = 2050 ANN-AVG HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR PEAKING POWER (TW)
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR PEAKING (TW) BEF T&D
C             BASEHYD, PEAKHYD, AND TURBHYD ARE ALL BEFORE T&D LOSSES
C BASHAFT   = 2050 REGIONAL DELIVERED HYDRO FOR BASELOAD AFTER T&D LOSSES (TW)
C PKHAFT    = 2050 REGIONAL DELIVERED HYDRO FOR PEAKING AFTER T&D LOSSES (TW)
C
      FRACOOL   = FRACOLD + FRACPCM
      CSPCHELC  = CSPCHARG - CSPCHSTO
      H1        = MAX(HYDISCHTW,SMAL30)
      H2        = MAX(PKHYDISCH,SMAL30)
      H3        = MAX(BASEHYD,  SMAL30)
C
      WRITE(IOUT,182)
     1  CSPCHELC *1E3,  CSPDISCH *1E3,    0.,                        0.,
     1  CSPCHSTO *1E3,  0.,               FRACCSP *STORTWH,FRACCSP*100.,
     1  TSTORPHS *1E3,  TSTORPHS *1E3,    FRACPHS *STORTWH,FRACPHS*100.,
     1  CHILDISCH*1E3,  CHILDISCH*1E3,    FRACOLD *STORTWH,FRACOLD*100.,
     1  PCMDISCH *1E3,  PCMDISCH *1E3,    FRACPCM *STORTWH,FRACPCM*100.,
     1  TSTORCOOL*1E3,  TSTORCOOL*1E3,    FRACOOL *STORTWH,FRACOOL*100.,
     1  BATDISCH *1E3,  BATDISCH *1E3,    FRACBAT *STORTWH,FRACBAT*100.,
     1  FCCHARG  *1E3,  FCDISCH  *1E3,    FRACHFC *STORTWH,FRACHFC*100.,
     1  HBTCHARG *1E3,  HBTDISCH *1E3,    FRACHBT *STORTWH,FRACHBT*100.,
     1  HOTCHARG *1E3,  HOTDISCH *1E3,    FRACHOT *STORTWH,FRACHOT*100.,
     1  CHARGTW  *1E3,  DISCHTW  *1E3,    STORTWH,         100.,
     1  TWINUTES *1E3,  UTESDISCH*1E3,    UTESTWH,         100.,
     1  UTESCHARG*1E3,  UTESDISCH*1E3,    UTESTWH,         100.,
     1  TURBHYD  *1E3,  HYDISCHTW*1E3,    HYDTWHMAX, HYDTWHMAX/H1,
     1  PEAKHYD  *1E3,  PKHYDISCH*1E3,    PKHYDMAX,  PKHYDMAX /H2,
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     1  BASEHYD  *1E3,  BASEHYD  *1E3,    BASHYDMX,  BASHYDMX /H3
C
 182  FORMAT('STORAGE-TECHNOL   GW-CHARGE    GW-DISCHARG  TWH-STOR    ',
     1       ' % OR HR(HYDRO)',/
     1       'CSP-ELEC         ',4(0PF13.6),/
     1       'CSP-PCM          ',4(0PF13.6),/
     1       'PUMPED HYDRO     ',4(0PF13.6),/
     1       'CHILLED-WAT-STES ',4(0PF13.6),/
     1       'PCM-ICE          ',4(0PF13.6),/
     1       'CW-STES+PCMICE   ',4(0PF13.6),/
     1       'BATTERIES        ',4(0PF13.6),/
     1       'H2 FOR GRID ELEC ',4(0PF13.6),/
     1       'HEAT BATTERIES   ',4(0PF13.6),/
     1       'HOT-WAT-STES     ',4(0PF13.6),/
     1       'NON-UTES, NON-H2 ',4(0PF13.6),/
     1       'UTES-FROMHEAT    ',4(0PF13.6),/
     1       'UTES-FROMELEC    ',4(0PF13.6),/
     1       'HYDRO-TOTAL      ',4(0PF13.6),/
     1       'PEAK HYDRO       ',4(0PF13.6),/
     1       'BASE HYDRO       ',4(0PF13.6),/)
C
      TGWCSPDIV = MAX(TGWCSP,SMAL30)
      WRITE(IOUT,183) CSPCHSTO/TWPERGW,
     1                CSPCHARG/TWPERGW,
     1                CSPDISCH/TWPERGW,
     1                CSPSTORGAT,
     1                CSPCHARG / (TWPERGW * TGWCSPDIV),
     1                CSPTURBFAC,
     1                CSPCHARFAC,
     1                CSPCHARG / (CSPDISCH + SMAL30),
     1                CSPCHSTO / (CSPDISCH + SMAL30),
     1                RATIOCSP,
     1                DAYBASHYD, HBASHY, HREFILL, HPEAKH,
     1                TURBHYD  *1E3, CURHYD*1E3,
     1                BASEHYD  *1E3, BASHAFT*1E3,
     1                PEAKHYD  *1E3, PKHAFT *1E3
C
 183  FORMAT(
     1 'CSPCHSTO-GW (MX CHARGE RATE CSP STORAGE        = ',1(0PF15.8),/
     1 'CSPCHARG-GW (MX CHARGE RATE CSP DIRECELEC+STOR = ',1(0PF15.8),/
     1 'CSPDISCH-GW (MX DISCHARGE RATE CSP             = ',1(0PF15.8),/
     1 'CSPSTORGAT ORIG                                = ',1(0PF15.8),/
     1 'CSPSTORGAT AFT= CSPCHARG*1E3/TGWCSP            = ',1(0PF15.8),/
     1 'CSPTURBFAC                                     = ',1(0PF15.8),/
     1 'CSCHARFAC = CSPTURBFAC * CSPSTORGAT            = ',1(0PF15.8),/
     1 'CSPCHARG/CSPDISCH                              = ',1(0PF15.8),/
     1 'CSPCHSTO/CSPDISCH                              = ',1(0PF15.8),/
     1 'RATIOCSP = CSPCHARG / TWCSPGAT                 = ',1(0PF15.8),/
     1 'DAYBASHYD, HBASHY-H HREFILL-H HPEAKH-H         = ',4(0PF15.8),/
     1 'TURBHYD CURHYD:  HYDRO BASE+PK BEF/AFT T&D-GW  = ',2(0PF15.8),/
     1 'BASEHYD BASHAFT: HYDRO BASELD  BEF/AFT T&D-GW  = ',2(0PF15.8),/
     1 'PEAKHYD PKHAF  : HYDRO PEAKING BEF/AFT T&D-GW  = ',2(0PF15.8)/)
C
      IF (ABS(SUMFRAC-1.).GT.0.00001) THEN
       WRITE(IOUT,*)'POWERWORLD: SUMFRAC NE 1 ',SUMFRAC
       STOP
      ENDIF
C
C ***************************************************************************
C         FACTORS FOR HEAT PUMPS POWERING HW/CW-STES AND UTES HEAT STORAGE
C ***************************************************************************
C COSTHPL  = LO COST ($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C COSTHPM  = MEAN COST ($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C COSTHPH  = HI COST ($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C            https://www.globalspec.com/reference/56411/203279/a-capital-cost-
C            comparison-of-commercial-ground-source-heat-pump-systems
C            WITH >500 TONS, COST $47/KW-TH ($165/TON=$13,750/(MMBtu/h))
C            12000 BTU/TON; 0.012 MMBtu/TON; 293.07107 kWh/MMBTu
C            ASSUME $47/KW-TH AT HIGH END 2050
C            ASSUME $40/KW-TH MEDIUM VALUE 2050
C            ASSUME $33/KW-TH LOW VALUE 2050
C
C            https://www.energy.gov/sites/prod/files/2014/05/f15/heatpump.pdf
C            293.07107 kWh/MMBtu, COP OF HEAT PUMPS = 4u
C            --> $50,000/(MMBtu/h) x 4kW-HEAT/4kW-ELEC / (293.07107 kWh/MMBtu)
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C            = $682.43/kW-ELEC
C CPERFORM = COEF OF PERFORMANCE OF HEAT PUMPS (KW-THERMAL/KW-ELEC)
C
      COSTHPL =  33.0 * CPERFORM
      COSTHPM =  40.0 * CPERFORM
      COSTHPH =  47.0 * CPERFORM
C
C CONVERT COSTS OF THERMAL ENERGY STORAGE (CW-STES, ICE, HW-STES,
C AND UTES) FROM $/KWH-TH TO $/KWH-ELEC SINCE ALL ENERGY IN MODEL
C IS CARRIED AND STORED AS ELECTRICITY.
C
C COLD ENERGY (AIR, WATER, ICE) ALREADY PRODUCED FROM ELECTRICITY
C SO ASSUME COP=1
C
C     COSTSTORL(ICWSTES) = COSTSTORL(ICWSTES) * CPERFORM
C     COSTSTORM(ICWSTES) = COSTSTORM(ICWSTES) * CPERFORM
C     COSTSTORH(ICWSTES) = COSTSTORH(ICWSTES) * CPERFORM
C     COSTSTORL(IPCMICE) = COSTSTORL(IPCMICE) * CPERFORM
C     COSTSTORM(IPCMICE) = COSTSTORM(IPCMICE) * CPERFORM
C     COSTSTORH(IPCMICE) = COSTSTORH(IPCMICE) * CPERFORM
C
      COSTSTORL(IHWSTES) = COSTSTORL(IHWSTES) * CPERFORM
      COSTSTORM(IHWSTES) = COSTSTORM(IHWSTES) * CPERFORM
      COSTSTORH(IHWSTES) = COSTSTORH(IHWSTES) * CPERFORM
      COSTUTESL          = COSTUTESL          * CPERFORM
      COSTUTESM          = COSTUTESM          * CPERFORM
      COSTUTESH          = COSTUTESH          * CPERFORM
C
C EFFCOLD   = AVERAGE ROUND-TRIP EFFICIENCY OF CW-STES + PCM-ICE STORAGE
C             ACCOUNTING FOR CHARGING, STORAGE, AND DISCHARGING.
C EFFCSTES  = ROUND-TRIP EFFICIENCY OF ELECTRIC WATER CHILLERS (WATER COOLED STES)
C EFFHSTES  = ROUND-TRIP EFFICIENCY OF ELECTRIC BOILER
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C
      IF (FRACOLD+FRACPCM.EQ.0.) THEN
       EFFCOLD = 0.5*EFFCSTES + 0.5*EFFPCM
      ELSE
       EFFCOLD = (FRACOLD*EFFCSTES+FRACPCM*EFFPCM)
     1         / (FRACOLD+FRACPCM)
      ENDIF
C
C STORETOT  = AVERAGE ROUND-TRIP EFFICIENCY OF NON-UTES STORAGE
C             ACCOUNTING FOR CHARGING, STORAGE, AND DISCHARGING.
C EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C             IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C             CELL EFFIC, ETC.
C
      STORETOT = FRACPHS * EFFPHS   + FRACOLD * EFFCSTES
     1         + FRACPCM * EFFPCM   + FRACHOT * EFFHSTES
     1         + FRACCSP * EFFCSP   + FRACBAT * EFFBAT
     1         + FRACHFC * EFFH2CD  + FRACHBT * EFFHTBAT

      WRITE(IOUT,178) (COSTSTORL(I),COSTSTORM(I),
     1                              COSTSTORH(I), I = 1, MXSTOR),
     1                COSTUTESL, COSTUTESM, COSTUTESH,
     1                COSTHPL,   COSTHPM,   COSTHPH,
     1                AVCAPLO(IHYDRO)*FELECHP*1E+09,
     1                AVCAPMN(IHYDRO)*FELECHP*1E+09,
     1                AVCAPHI(IHYDRO)*FELECHP*1E+09,
     1                EFFPHS,    FRACPHS,
     1                EFFCSTES,  FRACOLD,
     1                EFFPCM,    FRACPCM,
     1                EFFHSTES,  FRACHOT,
     1                EFFCOLD,   FRACOLD + FRACPCM,
     1                EFFBAT,    FRACBAT,
     1                EFFH2CD,   H2CHAREFF, H2DCEFF,  FRACHFC,
     1                EFFCSP,    FRACCSP,   EFFHTBAT, FRACHBT,
     1                STORETOT,
     1                EFFUTES
C
 178  FORMAT('COST PUMPED HYDRO STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST CW-SENS HEAT STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST PCM-CSP      STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST MIR-CSP      STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST PCM-ICE      STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
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     1       'COST HW-SENS HEAT STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST L-I BATTERY  STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST HI-T BRICK   STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST UTES         STOR($/KWH-EL) LO MN HI',3(0PF12.5),/
     1       'COST HEATPUMPS FORSTOR($/KW-EL)  LO MN HI',3(0PF12.5),/
     1       'COST ADDED HYDRO TURBS($/KW)     LO MN HI',3(0PF12.5),/
     1       'EFFPHS    FRACPHS                       ',2(0PF12.5),/
     1       'EFFCSTES  FRACOLD                       ',2(0PF12.5),/
     1       'EFFPCM    FRACPCM                       ',2(0PF12.5),/
     1       'EFFHSTES  FRACHOT                       ',2(0PF12.5),/
     1       'EFFCOLD   FRACOLD+FRACPCM               ',2(0PF12.5),/
     1       'EFFBAT    FRACBAT                       ',2(0PF12.5),/
     1       'EFFH2CD   H2CHAREFF H2DCEFF  FRACHFC    ',4(0PF12.5),/
     1       'EFFCSP    FRACCSP   EFFHTBAT FRACHBT    ',4(0PF12.5),/
     1       'AVG NON-UTES IN/OUT/STOR EFFIC          ',1(0PF12.5),/
     1       'AVG     UTES IN/OUT/STOR EFFICIENCY     ',1(0PF12.5),/)
C
C EFFCSP   = ROUND-TRIP EFFICIENCY OF CSP PHASE-CHANGE MATERIAL STORAGE (FRACTION)
C EFFPHS   = ROUND-TRIP EFFICIENCY OF PUMPED HYDRO (FRACTION ~ 0.8)
C EFFPCM   = ROUND-TRIP EFFICIENCY OF PCM-ICE STORAGE (FRACTION)
C EFFCSTES = ROUND-TRIP EFFICIENCY OF ELECTRIC WATER CHILLERS (WATER COOLED STES)
C EFFHSTES = ROUND-TRIP EFFICIENCY OF ELECTRIC BOILER
C EFFBAT   = ROUND-TRIP EFFICIENCY OF L-I BATTERY STORAGE (FRACTION)
C EFFUTES  = ROUND-TRIP EFFICIENCY OF UTES STORAGE (FRACTION)
C RTCSPEFF = SQRT(EFFCSP)
C          = FRACTION OF ENERGY IN CSP PHASE-CHANGE MATERIAL ADDED TO/REMOVED FROM
C            CSP THAT IS NOT LOST, DUE TO CHARGING & DISCHARGING
C            APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C RTPHSEFF = SQRT(EFFPHS).
C          = FRACTION OF ENERGY IN PUMPED-HYDRO STORAGE ADDED TO/REMOVED FROM
C            PHS THAT IS NOT LOST, DUE TO CHARGING & DISCHARGING
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C RTHTESEF = SQRT(EFFHSTES).
C          = FRACTION OF ENERGY IN HW-STES ADDED TO/REMOVED FROM
C            HW-STES THAT IS NOT LOST, FROM CHARGING & DISCHARGING
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C RTBATEFF = SQRT(EFFBAT)
C          = FRACTION OF ENERGY IN BATTERY STORAGE
C            THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C RTHBTEFF = SQRT(EFFHTBAT)
C          = FRACTION OF ENERGY IN HEAT BATTERY STORAGE
C            THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C RTCOLDEF = SQRT(EFFCOLD)
C          = FRACTION OF ENERGY IN CW-STES + PCM-ICE STORAGE
C            THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C            APPLY  SEPARATELY DURING CHARGING AND DISCHARGING.
C RTUGEFF  = SQRT(EFFUTES)
C          = FRACTION OF ENERGY IN HEATED FLUID ADDED TO/REMOVED
C            FROM UNDERGROUND STORAGE THAT IS NOT LOST DUE TO T&D LOSSES
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C            RTUGEFF^2=EFFUTES = OVERALL EFFIC OF HEATING SOIL OR WATER WITH
C            HEATED FLUID THEN RETURNING HEAT TO FLUID IN OPPOSITE SEASON AND
C            USING THE HEATED FLUID TO HEAT AIR OR WATER.
C            EFFUTES IS EFFICIENCY AFTER EITHER FLUID HAS ALREADY BEEN HEATED
C            FROM ELECTRICITY OR SUN
C
      RTCSPEFF = SQRT(EFFCSP)
      RTPHSEFF = SQRT(EFFPHS)
      RTHTESEF = SQRT(EFFHSTES)
      RTCOLDEF = SQRT(EFFCOLD)
      RTBATEFF = SQRT(EFFBAT)
      RTHBTEFF = SQRT(EFFHTBAT)
      RTUGEFF  = SQRT(EFFUTES)
C
C CAPCSPLO   = LOW CAPITAL COST OF CSP WITH ACTUAL AMOUNT STORAGE ($TRIL/MW)
C AVCAPLO    = AVERAGE (2013 TO 2050) LOW CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPMN    = AVERAGE (2013 TO 2050) MEAN CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPHI    = AVERAGE (2013 TO 2050) HI CAP COST PER GENERATOR ($TRIL/MW)
C RATIOSTOR  = RATIO OF CSP MIRROR CAPACITY (TW) TO GENERATOR CAPACITY (TW) - 1
C              DIVIDED BY THAT CORRESPONDING TO SYSTEM WITH COST AVCAP(ICSPSTOR)
C              (= 3.2) MINUS 1
C CSPCHARG   = MAX CHARGE RATE (TW) OF CSP DIRECT ELECTRICITY + STORAGE
C            = CSPDISCH + CSPCHSTO
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C              IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C              BASED ON SIZE OF MIRRORS (NOT SIZE OF GENERATOR)
C CSPDISCH   = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C            = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C              IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C RATIOCSPDAT= DEFAULT RATIO OF CSP CHARGE RATE TO DISCHARGE RATE FOR
C              'CSP WITH STORAGE' IN xlsx-spreadsheets COST CALCS. HERE, NEED
C               TO INTERPOLATE BETWEEN COST OF CSP WITH NO STORAGE AND THAT
C               WITH STORAGE USING RATIOSTOR TO OBTAIN COST WITH ACTUAL
C               CHARGE:DISCHARGE RATIO USED.
C
      RATIOCSPDAT = 3.2
      RATIOSTOR   = (CSPCHARG/(CSPDISCH+SMAL30)-1.)/(RATIOCSPDAT-1.)
C
      CAPCSPLO = AVCAPLO(ICSPNOST)+RATIOSTOR
     1                            *(AVCAPLO(ICSPSTOR)-AVCAPLO(ICSPNOST))
      CAPCSPMN = AVCAPMN(ICSPNOST)+RATIOSTOR
     1                            *(AVCAPMN(ICSPSTOR)-AVCAPMN(ICSPNOST))
      CAPCSPHI = AVCAPHI(ICSPNOST)+RATIOSTOR
     1                            *(AVCAPHI(ICSPSTOR)-AVCAPHI(ICSPNOST))
C
C EGWTOTAL  = (GW) INSTALLED NAMEPLATE CAPACITY OF EXISTING 2013 WWS
C              ELECTRIC POWER GENERATORS (DON'T INCLUDE
C              HEAT: TGWSHEAT + TGWGEOHT)
C ADDHPDIS  = ADDED HYDROPOWER INSTALLED DISCHARGE CAPACITY (MW)
C             DUE TO ADDITIONAL TURBINES/GENERATORS/TRANSFORMERS
C GWPERMW   = 0.001    GIGAWATTS (GW) PER MEGAWATT (MW)
C AREALKM2R = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C             WATERS) OF GRID REGION
C PDENINST  = INSTALLED POWER DENSITY (KM2/MW) OF ENERGY DEVICES
C             FROM 143-COUNTRY SPREADSHEET 'Country and technology list'
C             CELLS K4..N15. FOR WIND AND WAVE, THESE NUMBERS ARE SPACING
C             DENSITIES. FOR EVERYTHING ELSE, THEY ARE FOOTPRINTS. NO
C             VALUES ARE GIVEN FOR ROOFTOP PV SINCE THEY DON'T INVOLVE
C             NEW LAND.
C GWPERMW   = 0.001    GIGAWATTS (GW) PER MEGAWATT (MW)
C ANEWONWIN = LAND AREA (KM2) OF NEW ONSHORE WIND IN GRID REGION
C ALLONWIN  = LAND AREA (KM2) OF ALL ONSHORE WIND IN GRID REGION
C ANEWOFWIN = WATER AREA (KM2) OF NEW OFFSHORE WIND IN GRID REGION
C ALLOFWIN  = WATER AREA (KM2) OF ALL OFFSHORE WIND IN GRID REGION
C
      ANEWONWIN   = (TGWONWIND-EGWONWIND)*PDENINST(IONWIND)/GWPERMW
      ALLONWIN    =  TGWONWIND           *PDENINST(IONWIND)/GWPERMW
C
      ANEWOFWIN   = (TGWOFFWIND-EGWOFFWIND)*PDENINST(IOFFWIND)/GWPERMW
      ALLOFWIN    =  TGWOFFWIND            *PDENINST(IOFFWIND)/GWPERMW
C
      ANEWRESPV   = (TGWRESPV-EGWRESPV)*PDENINST(IRESPV)/GWPERMW
      ALLRESPV    =  TGWRESPV          *PDENINST(IRESPV)/GWPERMW
C
      ANEWCOMPV   = (TGWCOMPV-EGWCOMPV)*PDENINST(ICOMGVPV)/GWPERMW
      ALLCOMPV    =  TGWCOMPV          *PDENINST(ICOMGVPV)/GWPERMW
C
      ANEWUTILPV  = (TGWUTILPV-EGWUTILPV)*PDENINST(IUTILPV)/GWPERMW
      ALLUTILPV   =  TGWUTILPV           *PDENINST(IUTILPV)/GWPERMW
C
      ANEWCSPST   = (TGWCSP-EGWCSP)*PDENINST(ICSPSTOR)/GWPERMW
      ALLCSPST    =  TGWCSP        *PDENINST(ICSPSTOR)/GWPERMW
C
      ANEWGEOE    = (TGWGEOEL-EGWGEOEL)*PDENINST(IGEOEL)/GWPERMW
      ALLGEOE     =  TGWGEOEL          *PDENINST(IGEOEL)/GWPERMW
C
      ANEWHYDRO    = (TGWHYD-EGWHYD)*PDENINST(IHYDRO)/GWPERMW
      ALLHYDRO     =  TGWHYD        *PDENINST(IHYDRO)/GWPERMW
C
      ANEWWAVE     = (TGWWAVE-EGWWAVE)*PDENINST(IWAVE)/GWPERMW
      ALLWAVE      =  TGWWAVE         *PDENINST(IWAVE)/GWPERMW
C
      ANEWTIDAL    = (TGWTIDAL-EGWTIDAL)*PDENINST(ITIDAL)/GWPERMW
      ALLTIDAL     =  TGWTIDAL          *PDENINST(ITIDAL)/GWPERMW
C
      ANEWSOLH    = (TGWSHEAT-EGWSHEAT)*PDENINST(ISOLTHM)/GWPERMW
      ALLSOLH     =  TGWSHEAT          *PDENINST(ISOLTHM)/GWPERMW
C
      ANEWGEOH    = (TGWGEOHT-EGWGEOHT)*PDENINST(IGEOHT)/GWPERMW
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      ALLGEOH     =  TGWGEOHT          *PDENINST(IGEOHT)/GWPERMW
C
C ENEWFPNEWL = FOOTPRINT LAND (KM2) ALL NEW ELECTRIC GEN TECHS IN GRID REGION
C               ONSHORE WIND IS SPACING AREA SO IS NOT INCLUDED IN THIS
C EALLFPNEWL = FOOTPRINT LAND (KM2) ALL NEW+EXIST ELEC GEN TECHS IN GRID REGION
C
      ENEWFPNEWL  = ANEWUTILPV + ANEWCSPST + ANEWGEOE + ANEWHYDRO
      EALLFPNEWL  = ALLUTILPV  + ALLCSPST  + ALLGEOE  + ALLHYDRO
C
C ANEWFPNEWL = FOOTPRINT LAND AREA (KM2) OF ALL NEW ELEC+HEAT TECHS IN GRID REG
C ALLFPNEWL  = FOOTPRINT LAND AREA (KM2) OF ALL NEW+EXIST ELEC+HEAT TECHS IN REG
C AREA100    = CONVERTS KM2 LAND IN REGION TO PERCENT OF REGIONAL LAND AREA
C
      ANEWFPNEWL  = ENEWFPNEWL + ANEWSOLH + ANEWGEOH
      ALLFPNEWL   = EALLFPNEWL + ALLSOLH  + ALLGEOH
      AREA100     = 100. / AREALKM2R(IGRIDUSE)
C
      WRITE(IOUT,173) EGWONWIND , TGWONWIND , 1./PDENINST(IONWIND),
     1                 ANEWONWIN, ANEWONWIN * AREA100,
     1                 ALLONWIN,  ALLONWIN  * AREA100,
C
     1                EGWOFFWIND, TGWOFFWIND, 1./PDENINST(IOFFWIND),
     1                 ANEWOFWIN, ANEWOFWIN * AREA100,
     1                 ALLOFWIN,  ALLOFWIN  * AREA100,
C
     1                EGWRESPV  , TGWRESPV  , 1./PDENINST(IRESPV),
     1                 ANEWRESPV, ANEWRESPV * AREA100,
     1                 ALLRESPV,  ALLRESPV  * AREA100,
C
     1                EGWCOMPV  , TGWCOMPV  , 1./PDENINST(ICOMGVPV),
     1                 ANEWCOMPV, ANEWCOMPV * AREA100,
     1                 ALLCOMPV,  ALLCOMPV  * AREA100,
C
     1                EGWUTILPV , TGWUTILPV , 1./PDENINST(IUTILPV),
     1                 ANEWUTILPV, ANEWUTILPV * AREA100,
     1                 ALLUTILPV,  ALLUTILPV  * AREA100,
C
     1                EGWCSP    , TGWCSP    , 1./PDENINST(ICSPSTOR),
     1                 ANEWCSPST, ANEWCSPST * AREA100,
     1                 ALLCSPST,  ALLCSPST  * AREA100,
C
     1                EGWGEOEL  , TGWGEOEL  , 1./PDENINST(IGEOEL),
     1                 ANEWGEOE, ANEWGEOE * AREA100,
     1                 ALLGEOE,  ALLGEOE  * AREA100,
C
     1                EGWHYD    , TGWHYD    , 1./PDENINST(IHYDRO),
     1                 ANEWHYDRO, ANEWHYDRO * AREA100,
     1                 ALLHYDRO,  ALLHYDRO  * AREA100,
C
     1                0.        , ADDHPDIS*GWPERMW, 0., 0., 0., 0., 0.,
C
     1                EGWWAVE   , TGWWAVE   , 1./PDENINST(IWAVE),
     1                 ANEWWAVE, ANEWWAVE * AREA100,
     1                 ALLWAVE,  ALLWAVE  * AREA100,
C
     1                EGWTIDAL  , TGWTIDAL  , 1./PDENINST(ITIDAL),
     1                 ANEWTIDAL, ANEWTIDAL * AREA100,
     1                 ALLTIDAL,  ALLTIDAL  * AREA100,
C
     1                EGWTOTAL  , TGWTOTAL  , 0.,
     1                 ENEWFPNEWL, ENEWFPNEWL * AREA100,
     1                 EALLFPNEWL, EALLFPNEWL * AREA100,
C
     1                EGWSHEAT  , TGWSHEAT  , 1./PDENINST(ISOLTHM),
     1                 ANEWSOLH, ANEWSOLH * AREA100,
     1                 ALLSOLH,  ALLSOLH  * AREA100,
C
     1                EGWGEOHT  , TGWGEOHT  , 1./PDENINST(IGEOHT),
     1                 ANEWGEOH, ANEWGEOH * AREA100,
     1                 ALLGEOH,  ALLGEOH  * AREA100,
C
C THE TOTAL FOOTPRINT IS OF UTILITY PV, CSP, GEOTHERMAL, HYDRO.
C ONSHORE WIND IS SPACING AREA. ROOFTOP PV DOESN'T AKE NEW LAND, REST
C IS OFFSHORE
C
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     1               EGWTOTAL+EGWSHEAT+EGWGEOHT,
     1               TGWTOTAL+TGWSHEAT+TGWGEOHT, 0.,
     1                ANEWFPNEWL, ANEWFPNEWL * AREA100,
     1                ALLFPNEWL,  ALLFPNEWL  * AREA100
C
 173  FORMAT('GW NAMEPLATE CAPACITY          2020         2050       ',
     1       'INSTAL-MW/KM2 LANDNEWTECH-KM2 %REGLAND LANDALLTECH-KM2 ',
     1       '%REGLAND',/
     1       'ONSHORE WIND            ',6(0PF14.5),0PF10.5,/
     1       'OFFSHORE WIND           ',6(0PF14.5),0PF10.5,/
     1       'RESIDENTIAL PV          ',6(0PF14.5),0PF10.5,/
     1       'COMMERCIAL/GOVT PV      ',6(0PF14.5),0PF10.5,/
     1       'UTILITY-SCALE PV        ',6(0PF14.5),0PF10.5,/
     1       'CSP-ORIG+ADDED FOR GRID ',6(0PF14.5),0PF10.5,/
     1       'GEOTHERMAL-ELEC         ',6(0PF14.5),0PF10.5,/
     1       'HYDROELECTRIC           ',6(0PF14.5),0PF10.5,/
     1       'ADDED HYDRO DISCH CAPAC ',6(0PF14.5),0PF10.5,/
     1       'WAVE                    ',6(0PF14.5),0PF10.5,/
     1       'TIDAL                   ',6(0PF14.5),0PF10.5,/
     1       'TOTAL ELECTRICITY       ',6(0PF14.5),0PF10.5,/
     1       'SOLAR THERMAL HEAT      ',6(0PF14.5),0PF10.5,/
     1       'GEOTHERMAL HEAT         ',6(0PF14.5),0PF10.5,/
     1       'TOTAL ELEC+HEAT-FPRINT  ',6(0PF14.5),0PF10.5/)
C
      WRITE(IOUT,271) AREALKM2R(IGRIDUSE)
 271  FORMAT('LAND AREA OF GRID REGION (KM2) ',0PF11.2/)
C
C ***************************************************************************
C PRINT PRESENT-DAY NAMEPLATE CAPACITY FOR EACH GENERATOR BY STATE OR COUNTRY
C            ALSO PRINT LAND REQUIREMENTS & JOB CREATION/LOSS
C ***************************************************************************
C EGWINSTREG = GW-SUM OVER REG J, 2014 EXIST NAMEPL CAPAC FOR DEVICE K
C EGWINSTALL = EXISTING INSTALLED GW OF EACH 1..MXCAP DEVICE
C              1=ONSHORE WIND; 2=OFFSHORE WIND; 3=RESPV; 4=COM/GOV PV
C              5=UTILPV; 6=CSP; 7=0; 8=GEO-EL; 9=HYD; 10=TIDAL;
C              11=WAVE; 12=SOLAR THERMAL; 13= GEOHEAT
C
      WRITE(IOUT,346) NAMEGRID(IGRIDUSE),NCOUNGRID(IGRIDUSE)
      WRITE(IOUT,344) (EGWINSTREG(IGRIDUSE,K),K=1,MXCAP),
     1                EGWTOTAL+EGWSHEAT+EGWGEOHT
C
      DO I      = 1, NCOUNGRID(IGRIDUSE)
       ALLNP    = 0.
       DO K     = 1, MXCAP
        ALLNP   = ALLNNP + EGWINSTALL(IC,K)
       ENDDO
       IC       = NUMCOUNGR(IGRIDUSE,I)
       WRITE(IOUT,345) I, NAMCOUNGR(IGRIDUSE,I), IC,
     1                 (EGWINSTALL(IC,K),K=1,MXCAP), ALLNP
      ENDDO
C
C ***************************************************************************
C PRINT FINAL UPDATED NAMEPLATE CAPACITY FOR EACH GENERATOR BY STATE OR COUNTRY
C ***************************************************************************
C TGWCSPORIG = EXISTING + NEW GW OF CSP STEAM TURBINES INSTALLED. UPDATED HERE
C              TO INCREASE RATE OF DISCHARGE OF HEAT FROM STORAGE AS ELECTRICITY
C              (DOES NOT INCLUDE TMWCSPADD, WHICH IS WHY IT IS MULT BY CSPTURBFAC)
C TGWCSP     = EXISTING + NEW GW OF CSP STEAM TURBINES INSTALLED. AFTER UPDATE
C TGWINSTREG = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC FOR DEVICE K
C TGWINSTALL = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY IN 2050
C TGWTOTAL   = TOTAL (GW) INSTALLED NAMEPLATE CAPACITY OF ALL NEW PLUS
C              EXISTING 2050 WWS ELECTRIC POWER GENERATORS (DON'T INCLUDE
C              HEAT: TGWSHEAT + TGWGEOHT)
C ANEWFPNEWL = FOOTPRINT LAND AREA (KM2) OF ALL NEW ELEC+HEAT TECHS IN GRID REG
C AREA100    = CONVERTS KM2 LAND IN REGION TO PERCENT OF REGIONAL LAND AREA
C ANEWONWIN  = LAND AREA (KM2) OF NEW ONSHORE WIND IN GRID REGION
C
      WRITE(IOUT,144) NAMEGRID(IGRIDUSE),NCOUNGRID(IGRIDUSE)
      WRITE(IOUT,344) TGWONWIND,TGWOFFWIND,TGWRESPV,TGWCOMPV,TGWUTILPV,
     1                TGWCSP,0.,TGWGEOEL,TGWHYD,
     1                TGWTIDAL,TGWWAVE,TGWSHEAT,TGWGEOHT,
     1                TGWTOTAL+TGWSHEAT+TGWGEOHT,
     1                AREALKM2R(IGRIDUSE),
     1                ANEWFPNEWL, ANEWONWIN,
     1                ANEWFPNEWL*AREA100,  ANEWONWIN *AREA100
```

```
C
      SUMCAPC   = 0.
      DO I      = 1, NCOUNGRID(IGRIDUSE)
       IC       = NUMCOUNGR(IGRIDUSE,I)
C
       ALLNP    = 0.
       DO K     = 1, MXCAP
        IF (K.EQ.IONWIND) THEN
         TGREG  = TGWONWIND
        ELSEIF (K.EQ.IOFFWIND) THEN
         TGREG  = TGWOFFWIND
        ELSEIF (K.EQ.IRESPV) THEN
         TGREG  = TGWRESPV
        ELSEIF (K.EQ.ICOMGVPV) THEN
         TGREG  = TGWCOMPV
        ELSEIF (K.EQ.IUTILPV) THEN
         TGREG  = TGWUTILPV
        ELSEIF (K.EQ.ICSPSTOR) THEN
         TGREG  = TGWCSP
        ELSEIF (K.EQ.ICSPNOST) THEN
         TGREG  = 0.
        ELSEIF (K.EQ.IGEOEL) THEN
         TGREG  = TGWGEOEL
        ELSEIF (K.EQ.IHYDRO) THEN
         TGREG  = TGWHYD
        ELSEIF (K.EQ.ITIDAL) THEN
         TGREG  = TGWTIDAL
        ELSEIF (K.EQ.IWAVE) THEN
         TGREG  = TGWWAVE
        ELSEIF (K.EQ.ISOLTHM) THEN
         TGREG  = TGWSHEAT
        ELSEIF (K.EQ.IGEOHT) THEN
         TGREG  = TGWGEOHT
        ENDIF
C
C SCALE ORIGINAL NAMEPLATE CAPACITY IN COUNTRY BY RATIO OF FINAL
C NAMEPLATE CAPACITY IN REGION TO INITIAL NAMEPLATE CAPACITY IN REGION
C
C TGREG      = FINAL 2050 NAMEPLATE CAPAC(GW) EXIST+NEW GENERATORS IN REG
C TGWINSTALL = STATE/COUNTRY INIT 2050 NAMEPLATE CAPAC(GW) EXIST+NEW GENERATORS
C              BEFORE FACONWIN, ETC.
C TGWINSTREG = REGIONAL INIT 2050 NAMEPLATE CAPAC(GW) EXIST+NEW GENERATORS
C              BEFORE FACONWIN, ETC.
C GWFINAL    = FINAL 2050 NAMEPLATE CAPAC(GW) EXIST+NEW GENERATORS IN COUNTRY
C              TO MEET CONTINUOUS LOAD
C GWNEW      = NEW 2050 NAMEPLATE CAPAC(GW) OF NEW GENERATORS IN COUNTRY
C              TO MEET CONTINUOUS LOAD
C ALLNP      = GW-SUM COUNTRY IC, 2050 NEW+EXIST NAMEPL CAPAC ALL DEVICES
C EGWINSTALL = EXIST INSTALLED MW 1..MXCAP DEVICE BY COUNTRY
C
        GWFINAL(K) = TGWINSTALL(IC,K)*TGREG/TGWINSTREG(IGRIDUSE,K)
        GWNEW(  K) = GWFINAL(K) - EGWINSTALL(IC,K)
        ALLNP      = ALLNP + GWFINAL(K)
C
C ***************************************************************************
C         CALCULATE CAPITAL COST NEW GENERATORS BY STATE/COUNTRY
C ***************************************************************************
C GWNEW      = NEW 2050 NAMEPLATE CAPAC(GW) OF NEW GENERATORS IN COUNTRY
C              TO MEET CONTINUOUS LOAD
C GWPERMW    = 0.001 GIGAWATTS (GW) PER MEGAWATT (MW)
C CAPCOSC    = CUMULATIVE CAP COST ($TRIL) OF GENERATORS IN STATE/COUNTRY
C CAPCSPMN   = MEAN CAPITAL COST OF CSP WITH ACTUAL AMOUNT STORAGE ($TRIL/MW)
C AVCAPMN    = AVERAGE (2020 TO 2050) MEAN CAP COST PER GENERATOR ($TRIL/MW)
C
        IF (K.EQ.ICSPSTOR) THEN
         CAPCOSC(IC)= CAPCOSC(IC) + GWNEW(K) * CAPCSPMN/GWPERMW
        ELSE
         CAPCOSC(IC)= CAPCOSC(IC) + GWNEW(K) * AVCAPMN(K)/GWPERMW
        ENDIF
C
       ENDDO
C      ENDDO K = 1, MXCAP
C
C SUMCAPC = SUM OF CAPITAL COST ($TRIL) OF GENERATORS OVER ALL STATES/
C           COUNTRIES IN A REGION. SHOULD = TRILMN + TRILHMN
```

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C
      SUMCAPC = SUMCAPC + CAPCOSC(IC)
C
C FPRINTNEW  = FOOTPRINT LAND (KM2) ALL NEW ELECTRIC+HEAT GEN TECHS IN COUNTRY
C SPACENEW   = SPACING AREA (KM2) OF NEW ONSHORE WIND TURBINES
C PDENINST   = INSTALLED POWER DENSITY (KM2/MW) OF ENERGY DEVICES
C AREALKM2C  = LAND AREA (KM) (NOT INCLUDING INLAND WATER BODIES OR COASTAL
C              WATERS) OF COUNTRY
C AREA100    = CONVERTS KM2 LAND IN COUNTRY TO PERCENT OF COUNTRY LAND AREA
C
      FPRINTNEW  = (GWNEW(IUTILPV)  * PDENINST(IUTILPV)
     1            +  GWNEW(ICSPSTOR) * PDENINST(ICSPSTOR)
     1            +  GWNEW(IGEOEL)   * PDENINST(IGEOEL)
     1            +  GWNEW(IHYDRO)   * PDENINST(IHYDRO)
     1            +  GWNEW(ISOLTHM)  * PDENINST(ISOLTHM)
     1            +  GWNEW(IGEOHT)   * PDENINST(IGEOHT)) / GWPERMW
      SPACENEW   = GWNEW(IONWIND) * PDENINST(IONWIND) / GWPERMW
      AREA100    = 100. / AREALKM2C(IC)
C
      WRITE(IOUT,345) I, NAMCOUNGR(IGRIDUSE,I), IC,
     1                (GWFINAL(K),K=1,MXCAP), ALLNP,
     1                AREALKM2C(IC),FPRINTNEW, SPACENEW,
     1                FPRINTNEW*AREA100, SPACENEW*AREA100
      ENDDO
C     ENDDO I = 1, NCOUNGRID
      WRITE(IOUT,*)
C
 144   FORMAT(/'REG ',A14,'#SUB ',I3,' 2050NP  NEW+EX-GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
     1  'GW-SOLTH    GW-GEOHT    GW-TOT      LAND-KM2    NEWFP-KM2   ',
     1  'NEWSP-KM2   %NEWFPRIN   %NEWSPACING')
 344   FORMAT('      REGIONAL SUM ',         19X,14(1X,0PF11.5),
     1       3(1X,0PF11.0),2(1X,0PF11.5))
 345   FORMAT('   SUB-REGION   ',I3,1X,A14,1X,I3,14(1X,0PF11.5),
     1       3(1X,0PF11.0),2(1X,0PF11.5))
 346   FORMAT(/'REG ',A14,'#SUB ',I3,' 2020NP   EXIST-GW-ONWND    ',
     1  'GW-OFWND    GW-RESPV    GW-COMPV    GW-UTPV     GW-CSPOR    ',
     1  'GW-CSPAD    GW-GEOEL    GW-HYD      GW-TIDAL    GW-WAVE     ',
     1  'GW-SOLTH    GW-GEOHT    GW-TOT')
C
C SUMNEWINST = SUM OF NEW INSTALLED 2050 ELEC POWER GENERATORS (GW)
C SUMNEWHEAT = SUM OF NEW INSTALLED 2050 HEAT GENERATORS (GW)
C
      SUMNEWINST = AGWONWIND + AGWOFFWIND + AGWRESPV + AGWCOMPV
     1           + AGWUTILPV + AGWCSP     + AGWGEOEL + AGWHYD
     1           + AGWWAVE   + AGWTIDAL
C
      SUMNEWHEAT = AGWSHEAT + AGWGEOHT + SMAL30
C
C OPMAINTL  = LO ANNUAL OP & MAINT COST OF STORAGE AS FRAC OF CAP COST (0.01-0.02)
C OPMAINTM  = MN ANNUAL OP & MAINT COST OF STORAGE AS FRAC OF CAP COST (0.01-0.02)
C OPMAINTH  = HI ANNUAL OP & MAINT COST OF STORAGE AS FRAC OF CAP COST (0.01-0.02)
C             http://www.windmeasurementinternational.com/wind-turbines/
C             om-turbines.php
C
      OPMAINTL = 0.010
      OPMAINTH = 0.020
      OPMAINTM = 0.5 * (OPMAINTL + OPMAINTH)
C
C SDTRANSL  = LO SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C SDTRANSM  = MEAN SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C SDTRANSH  = HI SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C             FROM 50-STATE WWS "COST OF DELIVERED ELECTRICITY"
C SHORT-DIST TRANSMIS (1.15) & DISTRIBUTION (2.57) COSTS 3.72 CENTS/KWH
C     'Tables for 50-state paper' Table 6a
C      Trans & Distribution costs' TAB COLUMNS B/C & T/U
C
C     SDTRANSL = (1.0 + 1.2) / 2.
C     SDTRANSH = (1.0 + 1.4) / 2.
C     SDTRANSM = 0.5 * (SDTRANSL + SDTRANSH)
C
C DISTRIBL = LOW DISTRIBUTION COST (CENTS/KWH)
C DISTRIBM = MEANDISTRIBUTION COST (CENTS/KWH)
C DISTRIBH = HI DISTRIBUTION COST (CENTS/KWH)
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C             FROM 50-STATE WWS "COST OF DELIVERED ELECTRICITY"
C SHORT-DIST TRANSMIS (1.15) & DISTRIBUTION (2.57) COSTS 3.72 CENTS/KWH
C     'Tables for 50-state paper' Table 6a
C      Trans & Distribution costs' TAB COLUMNS B/C & T/U
C
      DISTRIBL = (2.5 + 2.1) / 2.
      DISTRIBH = (2.5 + 2.4) / 2.
      DISTRIBM = 0.5 * (DISTRIBL + DISTRIBH)
C
C ***************************************************************************
C               FACTORS FOR MOST TYPES OF STORAGE ANNUAL COSTS
C ***************************************************************************
C STORLIFEL = LIFETIME (YEARS) OF STORAGE DEVICES THAT GIVES LO COST
C STORLIFEM = LIFETIME (YEARS) OF STORAGE DEVICES THAT GIVES MN COST
C STORLIFEH = LIFETIME (YEARS) OF STORAGE DEVICES THAT GIVES HI COST
C
      STORLIFEL = 40.
      STORLIFEH = 25.
      STORLIFEM = 0.5 * (STORLIFEL + STORLIFEH)
C
C ANNFACSL = LO FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C            AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFEL
C ANNFACSM = MEAN FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C ANNFACSH = HI FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C
      ANNTERML   = (1. + DISCOUNTL)**STORLIFEL
      ANNTERMM   = (1. + DISCOUNTM)**STORLIFEM
      ANNTERMH   = (1. + DISCOUNTH)**STORLIFEH
C
      ANNFACSL = DISCOUNTL * ANNTERML / (ANNTERML - 1.)
      ANNFACSM = DISCOUNTM * ANNTERMM / (ANNTERMM - 1.)
      ANNFACSH = DISCOUNTH * ANNTERMH / (ANNTERMH - 1.)
C
C ***************************************************************************
C           FACTORS FOR GRID ELECTRICICTY BATTERY STORAGE ANNUAL COSTS
C ***************************************************************************
C STORLIFBL = 2050 LIFETIME (YEARS) OF LI-BATTERY DEVICES THAT GIVES LO COST
C STORLIFBM = 2050 LIFETIME (YEARS) OF LI-BATTERY THAT GIVES MN COST
C STORLIFBH = 2050LIFETIME (YEARS) OF LI-BATTERY THAT GIVES HI COST
C
      STORLIFBL = 22.
      STORLIFBH = 12.
      STORLIFBM = 0.5 * (STORLIFBL + STORLIFBH)
C
C ANNFACBL = LO FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C            AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFBL
C ANNFACBM = MEAN FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C ANNFACBH = HI FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C
      ANNTERML   = (1. + DISCOUNTL)**STORLIFBL
      ANNTERMM   = (1. + DISCOUNTM)**STORLIFBM
      ANNTERMH   = (1. + DISCOUNTH)**STORLIFBH
C
      ANNFACBL = DISCOUNTL * ANNTERML / (ANNTERML - 1.)
      ANNFACBM = DISCOUNTM * ANNTERMM / (ANNTERMM - 1.)
      ANNFACBH = DISCOUNTH * ANNTERMH / (ANNTERMH - 1.)
C
C ***************************************************************************
C         FACTORS FOR BRICK INDUSTRIAL HEAT BATTERY STORAGE ANNUAL COSTS
C ***************************************************************************
C STORLIFHBL = 2050 LIFETIME (YEARS) OF BRICK HEAT BATTERY THAT GIVES LO COST
C STORLIFHBM = 2050 LIFETIME (YEARS) OF BRICK HEAT BATTERY THAT GIVES MN COST
C            = 40 Y (FROM RONDO DATA SHEET FOR RHB300)
C STORLIFHBH = 2050 LIFETIME (YEARS) OF BRICK HEAT BATTERY THAT GIVES HI COST
C
      STORLIFHBL = 50.
      STORLIFHBM = 40.
      STORLIFHBH = 30.
C
C ANNFACBL = LO FACTOR TO MULT BRICK HEAT BAT CAP COST BY TO GET ANNUAL COST
C            AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFHBL
C ANNFACBM = MEAN FACTOR TO MULT BRICK HEAT BAT CAP COST BY TO GET ANNUAL COST
C ANNFACBH = HI FACTOR TO MULT BRICK HEAT BAT CAP COST BY TO GET ANNUAL COST
C
      ANNTERML   = (1. + DISCOUNTL)**STORLIFHBL
```

```
      ANNTERMM   = (1. + DISCOUNTM)**STORLIFHBM
      ANNTERMH   = (1. + DISCOUNTH)**STORLIFHBH
C
      ANNFACHBL = DISCOUNTL * ANNTERML / (ANNTERML - 1.)
      ANNFACHBM = DISCOUNTM * ANNTERMM / (ANNTERMM - 1.)
      ANNFACHBH = DISCOUNTH * ANNTERMH / (ANNTERMH - 1.)
C
C ***************************************************************************
C      FACTORS FOR HEAT PUMP FOR DISTRICT HEATING/COOLING ANNUAL COSTS
C ***************************************************************************
C HPLIFEL  = LIFETIME (YEARS) OF HEAT PUMP THAT GIVES LOW COST
C HPLIFEM  = LIFETIME (YEARS) OF HEAT PUMP THAT GIVES MEAN COST
C HPLIFEH  = LIFETIME (YEARS) OF HEAT PUMP THAT GIVES HIGH COST
C
      HPLIFEL = 50.
      HPLIFEM = 20.
      HPLIFEH = 10.
C
C ANFACHPL = LO FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C            AT DISCOUNT RATE DISCOUNTL AND LIFETIME HPLIFEL
C ANFACHPM = MEAN FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C ANFACHPH = HI FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C
      ANNTERML   = (1. + DISCOUNTL)**HPLIFEL
      ANNTERMM   = (1. + DISCOUNTM)**HPLIFEM
      ANNTERMH   = (1. + DISCOUNTH)**HPLIFEH
C
      ANFACHPL = DISCOUNTL * ANNTERML / (ANNTERML - 1.)
      ANFACHPM = DISCOUNTM * ANNTERMM / (ANNTERMM - 1.)
      ANFACHPH = DISCOUNTH * ANNTERMH / (ANNTERMH - 1.)
C
C ***************************************************************************
C                 FACTORS FOR WWS ENERGY  GENERATOR ANNUAL COSTS
C ***************************************************************************
C YEARLIFEL = LIFETIME (YEARS) OF WWS DEVICES THAT GIVES LO COST
C YEARLIFEH = LIFETIME (YEARS) OF WWS DEVICES THAT GIVES HI COST
C DISCOUNT  = DISCOUNT RATE (FRACTION)
C ANNFACL   = LO FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFEL
C ANNFACM   = MEAN FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C ANNFACH   = HI FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C
      DO I        = 1, MXCAP
       ANNTERML   = (1. + DISCOUNTL)**YEARLIFEL(I)
       ANNTERMM   = (1. + DISCOUNTM)**YEARLIFEM(I)
       ANNTERMH   = (1. + DISCOUNTH)**YEARLIFEH(I)
C
       ANNFACL(I) = DISCOUNTL * ANNTERML / (ANNTERML - 1.)
       ANNFACM(I) = DISCOUNTM * ANNTERMM / (ANNTERMM - 1.)
       ANNFACH(I) = DISCOUNTH * ANNTERMH / (ANNTERMH - 1.)
      ENDDO
C
C PGWINSTAL = GW OF NEW+EXISTING INSTALLATIONS OF EACH WWS POWER TYPE
C
      PGWINSTAL(IONWIND)  = TGWONWIND
      PGWINSTAL(IOFFWIND) = TGWOFFWIND
      PGWINSTAL(IRESPV)   = TGWRESPV
      PGWINSTAL(ICOMGVPV) = TGWCOMPV
      PGWINSTAL(IUTILPV)  = TGWUTILPV
      PGWINSTAL(ICSPNOST) = 0.
      PGWINSTAL(ICSPSTOR) = TGWCSP
      PGWINSTAL(IGEOEL)   = TGWGEOEL
      PGWINSTAL(IHYDRO)   = TGWHYD
      PGWINSTAL(IWAVE)    = TGWWAVE
      PGWINSTAL(ITIDAL)   = TGWTIDAL
      PGWINSTAL(ISOLTHM)  = TGWSHEAT
      PGWINSTAL(IGEOHT)   = TGWGEOHT
C
C AGWINSTAL = GW OF NEW INSTALLATIONS OF EACH WWS POWER TYPE
C
      AGWINSTAL(IONWIND)  = AGWONWIND
      AGWINSTAL(IOFFWIND) = AGWOFFWIND
      AGWINSTAL(IRESPV)   = AGWRESPV
      AGWINSTAL(ICOMGVPV) = AGWCOMPV
      AGWINSTAL(IUTILPV)  = AGWUTILPV
```

```
      AGWINSTAL(ICSPNOST) = 0.
      AGWINSTAL(ICSPSTOR) = AGWCSP
      AGWINSTAL(IGEOEL)   = AGWGEOEL
      AGWINSTAL(IHYDRO)   = AGWHYD
      AGWINSTAL(IWAVE)    = AGWWAVE
      AGWINSTAL(ITIDAL)   = AGWTIDAL
      AGWINSTAL(ISOLTHM)  = AGWSHEAT
      AGWINSTAL(IGEOHT)   = AGWGEOHT
C
      TRILLO    = 0.
      TRILMN    = 0.
      TRILHI    = 0.
C
      TRILHLO   = 0.
      TRILHMN   = 0.
      TRILHHI   = 0.
C
      OMPOWL    = 0.
      OMPOWM    = 0.
      OMPOWH    = 0.
C
      OMHEATL   = 0.
      OMHEATM   = 0.
      OMHEATH   = 0.
C
      ANCOSPOWL = 0.
      ANCOSPOWM = 0.
      ANCOSPOWH = 0.
C
      ANCOSHTL = 0.
      ANCOSHTM = 0.
      ANCOSHTH = 0.
C
C AMWINSTAL = MW OF NEW INSTALLATIONS OF EACH WWS POWER TYPE
C AGWINSTAL = GW OF NEW INSTALLATIONS OF EACH WWS POWER TYPE
C PMWINSTAL = MW OF NEW+EXIST INSTALLATIONS OF EACH WWS POWER TYPE
C PGWINSTAL = GW OF NEW+EXIST INSTALLATIONS OF EACH WWS POWER TYPE
C GWPERMW   = 0.001 GIGAWATTS (GW) PER MEGAWATT (MW)
C
      DO I        = 1, MXCAP
       AMWINSTALL = AGWINSTAL(I) / GWPERMW
       PMWINSTALL = PGWINSTAL(I) / GWPERMW
C
C ACAPCOSL  = LO UP-FRONT TOTAL CAP COST ($TRIL) ALL NEW WWS DEVICES OF EACH TYPE
C ACAPCOSM  = MN UP-FRONT TOTAL CAP COST ($TRIL) ALL NEW WWS DEVICES OF EACH TYPE
C ACAPCOSH  = HI UP-FRONT TOTAL CAP COST ($TRIL) ALL NEW WWS DEVICES OF EACH TYPE
C PCAPCOSL  = LO UP-FRONT TOTAL CAP COST ($TRIL) NEW+EXIST WWS DEVICES OF EACH TYPE
C PCAPCOSM  = MN UP-FRONT TOTAL CAP COST ($TRIL) NEW+EXIT WWS DEVICES OF EACH TYPE
C PCAPCOSH  = HI UP-FRONT TOTAL CAP COST ($TRIL) NEW+EXIST WWS DEVICES OF EACH TYPE
C CAPCSPLO  = LOW CAPITAL COST OF CSP WITH ACTUAL AMOUNT STORAGE ($TRIL/MW)
C CAPCSPHI  = HIGH CAPITAL COST OF CSP WITH ACTUAL AMOUNT STORAGE ($TRIL/MW)
C AVCAPLO   = AVERAGE (2015 TO 2050) LOW CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPMN   = AVERAGE (2015 TO 2050) MEAN CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPHI   = AVERAGE (2015 TO 2050) HI CAP COST PER GENERATOR ($TRIL/MW)
C
       IF (I.EQ.ICSPSTOR) THEN
        ACAPCOSL(I) = AMWINSTALL * CAPCSPLO
        ACAPCOSH(I) = AMWINSTALL * CAPCSPHI
        PCAPCOSL(I) = PMWINSTALL * CAPCSPLO
        PCAPCOSH(I) = PMWINSTALL * CAPCSPHI
       ELSE
        ACAPCOSL(I) = AMWINSTALL * AVCAPLO(I)
        ACAPCOSH(I) = AMWINSTALL * AVCAPHI(I)
        PCAPCOSL(I) = PMWINSTALL * AVCAPLO(I)
        PCAPCOSH(I) = PMWINSTALL * AVCAPHI(I)
       ENDIF
C
       ACAPCOSM(I) = 0.5 * (ACAPCOSL(I) + ACAPCOSH(I))
       PCAPCOSM(I) = 0.5 * (PCAPCOSL(I) + PCAPCOSH(I))
C
C CALCULATE CAPITAL COST OF NEW GENERATORS ONLY. HOWEVER, CALCULATE LCOE
C ASSUMING NEW+EXISTING GENERATORS SINCE ANNUAL COST WILL BE DIVIDED BY
C TOTAL ANNUAL ENERGY PRODUCTION
C
C TRILLO  = LOW UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS ELEC DEVICES
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C TRILMN  = MEAN UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS ELEC DEVICES
C TRILHI  = HI UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS ELEC DEVICES
C TRILHLO = LOW UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS HEAT DEVICES
C TRILHMN = MEAN UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS HEAT DEVICES
C TRILHHI = HI UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS HEAT DEVICES
C
       IF (I.EQ.ISOLTHM.OR.I.EQ.IGEOHT) THEN
        TRILHLO   = TRILHLO  + ACAPCOSL( I)
        TRILHMN   = TRILHMN  + ACAPCOSM( I)
        TRILHHI   = TRILHHI  + ACAPCOSH( I)
       ELSE
        TRILLO    = TRILLO  + ACAPCOSL( I)
        TRILMN    = TRILMN  + ACAPCOSM( I)
        TRILHI    = TRILHI  + ACAPCOSH( I)
       ENDIF
C
C OMPOWL    = SUMMED ANNUAL LO O&M COST ($TRIL) OVER NEW+EXIST ELEC GENERATORS
C OMPOWM    = SUMMED ANNUAL MEANN O&M COST ($TRIL) OVER NEW+EXISTELEC GENERATORS
C OMPOWH    = SUMMED ANNUAL HI O&M COST ($TRIL) OVER NEW+EXIT ELEC GENERATORS
C OMHEATL   = SUMMED ANNUAL LO O&M COST ($TRIL) OVER NEW+EXIST HEAT GENERATORS
C OMHEATM   = SUMMED ANNUAL MEANN O&M COST ($TRIL) OVER NEW+EXIT HEAT GENERATORS
C OMHEATH   = SUMMED ANNUAL HI O&M COST ($TRIL) OVER NEW+EXIT HEAT GENERATORS
C AGWINSTAL = GW OF NEW INSTALLATIONS OF EACH WWS POWER TYPE
C OANDMLO   = LOW VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C OANDMMN   = MEAN VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C OANDMHI   = HI  VARIABLE PLUS FIXED O&M COSTS ($/KW/YR) FOR WWS GENERATORS
C AKWPGW    = 1.0E+06  KILOWATTS (KW) PER GIGAWATT (GW)
C TRILPDOL  = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C
       IF (I.EQ.ISOLTHM.OR.I.EQ.IGEOHT) THEN
        OMHEATL  = OMHEATL + PGWINSTAL(I) * OANDMLO(I) * AKWPGW*TRILPDOL
        OMHEATM  = OMHEATM + PGWINSTAL(I) * OANDMMN(I) * AKWPGW*TRILPDOL
        OMHEATH  = OMHEATH + PGWINSTAL(I) * OANDMHI(I) * AKWPGW*TRILPDOL
       ELSE
        OMPOWL   = OMPOWL + PGWINSTAL(I) * OANDMLO(I) * AKWPGW*TRILPDOL
        OMPOWM   = OMPOWM + PGWINSTAL(I) * OANDMMN(I) * AKWPGW*TRILPDOL
        OMPOWH   = OMPOWH + PGWINSTAL(I) * OANDMHI(I) * AKWPGW*TRILPDOL
       ENDIF
C
C ANCOSPOWL = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWM = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWH = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSHTL  = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTM  = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTH  = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C DECOMLO   = LOW DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMMN   = MEAN DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C DECOMHI   = HIGH DECOMISSIONING COST AS FRACTION OF OVERNIGHT CAPITAL COST
C
       IF (I.EQ.ISOLTHM.OR.I.EQ.IGEOHT) THEN
        ANCOSHTL = ANCOSHTL + PCAPCOSL(I) * (1.+DECOMLO(I)) * ANNFACL(I)
        ANCOSHTM = ANCOSHTM + PCAPCOSM(I) * (1.+DECOMMN(I)) * ANNFACM(I)
        ANCOSHTH = ANCOSHTH + PCAPCOSH(I) * (1.+DECOMHI(I)) * ANNFACH(I)
       ELSE
        ANCOSPOWL = ANCOSPOWL + PCAPCOSL(I) * (1.+DECOMLO(I))*ANNFACL(I)
        ANCOSPOWM = ANCOSPOWM + PCAPCOSM(I) * (1.+DECOMMN(I))*ANNFACM(I)
        ANCOSPOWH = ANCOSPOWH + PCAPCOSH(I) * (1.+DECOMHI(I))*ANNFACH(I)
       ENDIF
C
      ENDDO
C     ENDDO I = 1, MXCAP
C
      ANCOSPOWL  = ANCOSPOWL + OMPOWL
      ANCOSPOWM  = ANCOSPOWM + OMPOWL
      ANCOSPOWH  = ANCOSPOWH + OMPOWL
C
      ANCOSHTL   = ANCOSHTL + OMHEATL
      ANCOSHTM   = ANCOSHTM + OMHEATL
      ANCOSHTH   = ANCOSHTH + OMHEATL
C
C SUMNEWINST = SUM OF NEW INSTALLED 2050 ELEC POWER GENERATORS (GW)
C SUMNEWHEAT = SUM OF NEW INSTALLED 2050 HEAT GENERATORS (GW)
C AVLOCAPCST = AVG LO CAPITAL COST OF ALL NEW ELEC INSTALLATIONS 2050 ($MIL/MW)
C AVMNCAPCST = AVG MEAN CAP COST OF ALL NEW ELEC INSTALLATIONS 2050 ($MIL/MW)
C AVHICAPCST = AVG HI CAPITAL COST OF ALL NEW ELEC INSTALLATIONS 2050 ($MIL/MW)
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C              THESE DO NOT INCLUDE DECOMMISSIONG
C AVLOCAPHT  = AVG LO CAPITAL COST OF ALL NEW HEAT INSTALLATIONS 2050 ($MIL/MW)
C AVMNCAPHT  = AVG MEAN CAP COST OF ALL NEW HEAT INSTALLATIONS 2050 ($MIL/MW)
C AVHICAPHT  = AVG HI CAPITAL COST OF ALL NEW HEAT INSTALLATIONS 2050 ($MIL/MW)
C              THESE DO NOT INCLUDE DECOMMISSIONG
C TRILLO     = LOW UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS DEVICES
C TRILMN     = MEAN UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS DEVICES
C TRILHI     = HI UP FRONT CAPITAL COST ($TRILLION) OF ALL NEW WWS DEVICES
C
      AVLOCAPCST = TRILLO * GWPTW / SUMNEWINST
      AVMNCAPCST = TRILMN * GWPTW / SUMNEWINST
      AVHICAPCST = TRILHI * GWPTW / SUMNEWINST
C
      AVLOCAPHT  = TRILHLO * GWPTW / SUMNEWHEAT
      AVMNCAPHT  = TRILHMN * GWPTW / SUMNEWHEAT
      AVHICAPHT  = TRILHHI * GWPTW / SUMNEWHEAT
C
C TSTORPHS  = MAX CHARGE RATE PUMPED HYDRO STORAGE (TW) = 57.683 GW 2010 U.S.
C TEXISTPHS = EXISTING PUMPED-HYDRO STORAGE (PHS) INSTALLED CAPACITY (TW)
C STORCTWH  = MAX STORAGE CAPACITY (TWH) OF CSP STORAGE
C STORPTWH  = MAX STORAGE CAPACITY (TWH) OF PHS STORAGE
C STOROTWH  = MAX STORAGE CAPACITY (TWH) OF CW-STES + PCM-ICE STORAGE
C STORBTWH  = MAX STORAGE CAPACITY (TWH) OF BATTERY STORAGE
C STORFTWH  = MAX STORAGE CAPACITY (TWH) OF ENERGY TO MAKE H2 FOR GRID ELEC STORAGE
C           = ENERGY IN ELECTRICITY USED TO PRODUCE/COMPRESS HYDROGEN
C             MULT STORFTWH BY H2CHAREFF TO GET MAX ENERGY IN H2 IN STORAGE
C           = MAX H2 IN STORAGE (TG-H2) * H2ENERGY (KWH/KG-H2)
C           = MAX ENERGY FROM FUEL CELL (TWH) / (H2DCEFF*H2CHAREFF)
C           = FCDISCH (TW) * STORHHFC (HOURS) / (H2DCEFF*H2CHAREFF)
C           = H2SDISCH TW) * STORHHFC(HOURS)
C           = 0 WHEN IMERGH2 = 1,3 OR 0
C STORHTWH  = MAX STORAGE CAPACITY (TWH) OF HW-STES STORAGE
C STORWTWH  = MAX STORAGE CAPACITY (TWH) OF CW-STES STORAGE
C STORITWH  = MAX STORAGE CAPACITY (TWH) OF PCM-ICE STORAGE
C COSTSTORL = LO LIFECYCLE COST OF STORAGE ($/KWH-EL)
C COSTSTORM = MEAN LIFECYCLE COST OF STORAGE ($/KWH-EL)
C COSTSTORH = HI LIFECYCLE COST OF STORAGE ($/KWH-EL)
C ADDHPDIS  = ADDED HYDROPOWER INSTALLED DISCHARGE CAPACITY (MW)
C             DUE TO ADDITIONAL TURBINES/GENERATORS/TRANSFORMERS
C             COST FROM IRENA (2012) RENEW ENERGY TECHS: COST ANAL FIG 4.7
C             http://www.irena.org/documentdownloads/publications/
C              re_technologies_cost_analysis-hydropower.pdf
C FELECHP   = FRACTION OF TOTAL CAPITAL COST OF HYDROPOWER THAT IS FOR
C             ELECTRICAL EQUIPMENT (TURBINES/GENERATORS/TRANSFORMERS
C             ~16% ($556/KW) 500 MW PLANT TOT COST $3,500 (FIG 4.5 IRENA 2012)
C             ($200-300/KW) 1000 MW PLANTS FIG. 4.7
C AVCAPLO   = AVERAGE (2015 TO 2050) LOW CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPMN   = AVERAGE (2015 TO 2050) MEAN CAP COST PER GENERATOR ($TRIL/MW)
C AVCAPHI   = AVERAGE (2015 TO 2050) HI CAP COST PER GENERATOR ($TRIL/MW)
C AKWPTW   = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KWH PER TWH
C TRILPDOL = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C AKWTRIL  = (KWH PER TWH) * (TRILLION DOLLARS PER DOLLAR)
C
      AKWTRIL   = AKWPTW * TRILPDOL
C
C STATIONARY BATTERY STORAGE
C  TRILBATL  = LOW TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C  TRILBATM  = MED TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C  TRILBATH  = HI TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C
      TRILBATL  =  STORBTWH * COSTSTORL(ILIB) * AKWTRIL
      TRILBATM  =  STORBTWH * COSTSTORM(ILIB) * AKWTRIL
      TRILBATH  =  STORBTWH * COSTSTORH(ILIB) * AKWTRIL
C
C ALL NON-BATTERY ELECTRICITY STORAGE (CSP-PCM, PHS)
C  TRILSTORL = LOW TOTAL UPFRONT LIFECYCLE COST CSP-PCM, PHS STORAGE ($TRIL)
C  TRILSTORM = MED TOTAL UPFRONT LIFECYCLE COST CSP-PCM, PHS STORAGE ($TRIL)
C  TRILSTORH = HI TOTAL UPFRONT LIFECYCLE COST CSP-PCM, PHS STORAGE ($TRIL)
C
      TRILSTORL = ((TSTORPHS-TEXISTPHS)*STORHPHS*COSTSTORL(IPHS)
     1          +   STORCTWH * COSTSTORL(IPCMCSP)) * AKWTRIL
      TRILSTORM = ((TSTORPHS-TEXISTPHS)*STORHPHS*COSTSTORM(IPHS)
     1          +   STORCTWH * COSTSTORM(IPCMCSP)) * AKWTRIL
      TRILSTORH = ((TSTORPHS-TEXISTPHS)*STORHPHS*COSTSTORH(IPHS)
     1          +   STORCTWH * COSTSTORH(IPCMCSP)) * AKWTRIL
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C
C HW-STES STORAGE (HOT WATER STORAGE)
C  TRILHTSTL = LOW TOTAL UPFRONT LIFECYCLE COST HW-STES STORAGE ($TRIL)
C  TRILHTSTM = MED TOTAL UPFRONT LIFECYCLE COST HW-STES STORAGE ($TRIL)
C  TRILHTSTH = HI TOTAL UPFRONT LIFECYCLE COST HW-STES STORAGE ($TRIL)
C  CPERFORM  = COEF OF PERFORMANCE OF HEAT PUMPS (KW-THERMAL/KW-ELEC)
C  COSTSTORL = LO LIFECYCLE COST OF STORAGE ($/KWH-ELEC) (CONVERTED
C              EARLIER FROM $/KWH-TH)
C              COST SHOULD BE BASED ON KWH-ELEC SINCE ALL ENERGY=ELECTRICITY.
C  `           HEAT CONVERTED TO ELECTRICITY ASSUMING HEAT PUMPS WITH CPERFORM
C
      TRILHTSTL =   STORHTWH * COSTSTORL(IHWSTES) * AKWTRIL
      TRILHTSTM =   STORHTWH * COSTSTORM(IHWSTES) * AKWTRIL
      TRILHTSTH =   STORHTWH * COSTSTORH(IHWSTES) * AKWTRIL
C
C CW-STES (CHILLED-WATER) + PCM-ICE (ICE) STORAGE
C  TRILCLSTL = LOW TOTAL UPFRONT LIFECYCLE COST CW-STES, PCM-ICE STORAGE ($TRIL)
C  TRILCLSTM = MED TOTAL UPFRONT LIFECYCLE COST CW-STES, PCM-ICE STORAGE ($TRIL)
C  TRILCLSTH = HI TOTAL UPFRONT LIFECYCLE COST CW-STES, PCM-ICE STORAGE ($TRIL)
C
      TRILCLSTL = (STORWTWH * COSTSTORL(ICWSTES)
     1          +  STORITWH * COSTSTORL(IPCMICE)) * AKWTRIL
      TRILCLSTM = (STORWTWH * COSTSTORM(ICWSTES)
     1          +  STORITWH * COSTSTORM(IPCMICE)) * AKWTRIL
      TRILCLSTH = (STORWTWH * COSTSTORH(ICWSTES)
     1          +  STORITWH * COSTSTORH(IPCMICE)) * AKWTRIL
C
C TRILADHPL = LO UPFRONT LIFECYCLE COST ADDITION HYDROPOWER TURBINES ($ TRIL)
C TRILADHPM = MED UPFRONT LIFECYCLE COST ADDITION HYDROPOWER TURBINES ($ TRIL)
C TRILADHPH = HI UPFRONT LIFECYCLE COST ADDITION HYDROPOWER TURBINES ($ TRIL)
C
      TRILADHPL = ADDHPDIS * FELECHP * AVCAPLO(IHYDRO)
      TRILADHPM = ADDHPDIS * FELECHP * AVCAPMN(IHYDRO)
      TRILADHPH = ADDHPDIS * FELECHP * AVCAPHI(IHYDRO)
C
C TRILUGSTL = LO UPFRONT LIFECYLCE COST UTES (UNDERGROUND HEAT STOR) ($ TRIL)
C TRILUGSTM = MED UPFRONT LIFECYLCE COST UTES (UNDERGROUND HEAT STOR) ($ TRIL)
C TRILUGSTH = HI UPFRONT LIFECYLCE COST UTES (UNDERGROUND HEAT STOR) ($ TRIL)
C UTESTWH   = MAX STORAGE CAPACITY (TWH-ELEC) UNDERGROUND HEAT STORAGE IN SOIL
C             IN UNITS OF TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C COSTUTESL = LO LIFECYCLE COST OF UTES STORAGE ($/KWH-ELEC)
C             CONVERTED EARLIER FROM $/KWH-TH WITH CPERFORM
C COSTUTESM = MEAN LIFECYCLE COST OF UTES STORAGE ($/KWH-ELEC)
C COSTUTESH = HI LIFECYCLE COST OF UTES STORAGE ($/KWH-ELEC)
C CPERFORM = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C            (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C
      TRILUGSTL = UTESTWH * COSTUTESL * AKWTRIL
      TRILUGSTM = UTESTWH * COSTUTESM * AKWTRIL
      TRILUGSTH = UTESTWH * COSTUTESH * AKWTRIL
C
C TRILHBTL  = LO UPFRONT LIFECYLCE COST BRICK HEAT BATTERY STORAGE ($ TRIL)
C TRILHBTM  = MED UPFRONT LIFECYLCE COST BRICK HEAT BATTERY STORAGE ($ TRIL)
C TRILHBTH  = HI UPFRONT LIFECYLCE COST BRICK HEAT BATTERY STORAGE ($ TRIL)
C STOHBTWH  = MAX STORAGE CAPACITY (TWH-THERMAL) OF BRICK HEAT BATTERY STORAGE
C COSTSTORL = LO LIFECYCLE COST OF BRICK HEAT-BATTERY STORAGE ($/KWH-TH)
C COSTSTORM = MED LIFECYCLE COST OF BRICK HEAT-BATTERY STORAGE ($/KWH-TH)
C COSTSTORH = HI LIFECYCLE COST OF BRICK HEAT-BATTERY STORAGE ($/KWH-TH)
C CPERFORM  = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C             (J-TH/J-ELEC = = KWH-TH/KWH-ELEC = KW-TH/KW-ELEC)
C
      TRILHBTL = STOHBTWH * COSTSTORL(IHTBAT) * AKWTRIL
      TRILHBTM = STOHBTWH * COSTSTORM(IHTBAT) * AKWTRIL
      TRILHBTH = STOHBTWH * COSTSTORH(IHTBAT) * AKWTRIL
C
C TRILSHPL  = LOW CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILSHPM  = MED CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILSHPH  = HI  CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C AKWTRIL   = (KWH PER TWH) * (TRILLION DOLLARS PER DOLLAR)
C HOTCHARG  = MAX CHARGE RATE (TW) OF HOT WATER (HW)-STES
C             REALLY MAX CHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
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C UTESCHARG = MAX CHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             FROM EXCESS ELECTRIC POWER GENERATION
C             SINCE LOW-TEMP HEAT LOAD IN countrystats.dat ALREADY
C             CONVERTED TO EQUIVALENT ELECTRICAL LOAD ASSUMING
C             HEAT PUMPS WITH CPERFORM, UTESCCHARG IS REALLY THE CHARGE
C             RATE OF EQUIV ELECTRICITY TO GIVE HEATING FROM HEAT PUMPS
C COSTHPL   = LO COST($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C COSTHPM   = MEAN COST($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C COSTHPH   = HI COST($/KW-ELEC) LARGE HEAT PUMPS TO CHARGE HW/CW-STES+UTES STORAGE
C AKWTRIL   = (KWH PER TWH) * (TRILLION DOLLARS PER DOLLAR)
C CHILDISCH = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C HPSIZE    = SIZE (TW-ELEC) OF HEAT PUMPS TO HEAT HW-STES+UTES
C             AND TO COOL CW-STES, ICE
C TRILHPL   = LOW TOTAL UPFRONT LIFECYCLE COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILHPM   = MED TOTAL UPFRONT LIFECYCLE COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILHPH   = HI  TOTAL UPFRONT LIFECYCLE COST HEAT PUMPS FOR HW/CW-STES+UTES
C
      HPSIZE    = MAX(HOTCHARG+UTESCHARG,CHILDISCH+PCMDISCH)
C
      TRILSHPL  = HPSIZE * COSTHPL * AKWTRIL
      TRILSHPM  = HPSIZE * COSTHPM * AKWTRIL
      TRILSHPH  = HPSIZE * COSTHPH * AKWTRIL
C
C TRILTOTL = LOW UP-FRONT CAPITAL COST ($TRILLION) OF NEW WWS DEVICES + STORAGE
C          + HEAT PUMPS FOR HW/CW-STES+UTES  STORAGE
C            EXCLUDES LONG-DISTANCE TRANSMISSION AND H2 COST, WHICH ARE
C            ADDED LATER. INCLUDES SHORT-DISTANCE TRANSMISSION
C            ALSO EXCLUDES DECOMMISSIONING, WHICH IS ADDED IN TERM DECOMIS
C TRILTOTM = MEAN UP-FRONT CAPITAL COST ($TRILLION) OF NEW WWS DEVICES + STORAGE
C TRILTOTH = HI UP-FRONT CAPITAL COST ($TRILLION) OF NEW WWS DEVICES + STORAGE
C
      TRILTOTL = TRILLO    + TRILHLO + TRILSTORL + TRILADHPL + TRILUGSTL
     1         + TRILSHPL  + TRILHTSTL + TRILCLSTL + TRILBATL + TRILHBTL
      TRILTOTM = TRILMN    + TRILHMN + TRILSTORM + TRILADHPM + TRILUGSTM
     1         + TRILSHPM  + TRILHTSTM + TRILCLSTM + TRILBATM + TRILHBTM
      TRILTOTH = TRILHI    + TRILHHI + TRILSTORH + TRILADHPH + TRILUGSTH
     1         + TRILSHPH  + TRILHTSTH + TRILCLSTH + TRILBATH + TRILHBTH
C
C ANCOSSTOL = LOW  ANNUAL TOTAL (CAP+O&M) COST CSP-PCM,PHS STOR ($TRIL/YR)
C ANCOSSTOM = MED  ANNUAL TOTAL (CAP+O&M) COST CSP-PCM,PHS STOR ($TRIL/YR)
C ANCOSSTOH = HI   ANNUAL TOTAL (CAP+O&M) COST CSP-PCM,PHS STOR ($TRIL/YR)
C ANNFACSL  = LO FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFEL
C ANNFACSM  = MEAN FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C ANNFACSH  = HI FACTOR TO MULTIPLY CAPITAL STORAGE COST BY TO GET ANNUAL COST
C OPMAINTL  = LO ANNUAL OP & MAINT COST OF STORAGE AS FRAC CAP COST
C OPMAINTM  = MN ANNUAL OP & MAINT COST OF STORAGE AS FRAC CAP COST
C OPMAINTH  = HI ANNUAL OP & MAINT COST OF STORAGE AS FRAC CAP COST
C
      ANCOSSTOL = TRILSTORL * (ANNFACSL + OPMAINTL)
      ANCOSSTOM = TRILSTORM * (ANNFACSM + OPMAINTM)
      ANCOSSTOH = TRILSTORH * (ANNFACSH + OPMAINTH)
C
C ANCOSBATL = LOW  ANNUAL TOTAL (CAP+O&M) COST LI-BATTERY STOR ($TRIL/YR)
C ANCOSBATM = MED  ANNUAL TOTAL (CAP+O&M) COST LI-BATTERY STOR ($TRIL/YR)
C ANCOSBATH = HI   ANNUAL TOTAL (CAP+O&M) COST LI-BATTERY STOR ($TRIL/YR)
C TRILBATL  = LOW TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C TRILBATM  = MED TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C TRILBATH  = HI TOTAL UPFRONT LIFECYCLE COST LI-BAT STORAGE ($TRIL)
C ANNFACBL  = LO FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME STORLIFBL
C ANNFACBM  = MEAN FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C ANNFACBH  = HI FACTOR TO MULTIPLY CAPITAL BATTERY COST BY TO GET ANNUAL COST
C
      ANCOSBATL = TRILBATL * (ANNFACBL + OPMAINTL)
      ANCOSBATM = TRILBATM * (ANNFACBM + OPMAINTM)
      ANCOSBATH = TRILBATH * (ANNFACBH + OPMAINTH)
C
C ANCHTSTOL = LOW ANNUAL TOTAL (CAP+O&M) COST HW-STES STORAGE ($TRIL/YR)
C ANCHTSTOM = MED ANNUAL TOTAL (CAP+O&M) COST HW-STES STORAGE ($TRIL/YR)
C ANCHTSTOH = HI  ANNUAL TOTAL (CAP+O&M) COST HW-STES STORAGE ($TRIL/YR)
C
      ANCHTSTOL = TRILHTSTL * (ANNFACSL + OPMAINTL)
      ANCHTSTOM = TRILHTSTM * (ANNFACSM + OPMAINTM)
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      ANCHTSTOH = TRILHTSTH * (ANNFACSH + OPMAINTH)
C
C ANCCLSTOL = LOW ANNUAL TOTAL (CAP+O&M) COST CW-STES+PCM-ICE STORAGE ($TRIL/YR)
C ANCCLSTOM = MED ANNUAL TOTAL (CAP+O&M) COST CW-STES+PCM-ICE STORAGE ($TRIL/YR)
C ANCCLSTOH = HI  ANNUAL TOTAL (CAP+O&M) COST CW-STES+PCM-ICE STORAGE ($TRIL/YR)
C
      ANCCLSTOL = TRILCLSTL * (ANNFACSL + OPMAINTL)
      ANCCLSTOM = TRILCLSTM * (ANNFACSM + OPMAINTM)
      ANCCLSTOH = TRILCLSTH * (ANNFACSH + OPMAINTH)
C
C ANCOSHPTL = LOW  ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTM = MEAN ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTH = HIGH ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C
      ANCOSHPTL = TRILADHPL * (ANNFACSL + OPMAINTL)
      ANCOSHPTM = TRILADHPM * (ANNFACSM + OPMAINTM)
      ANCOSHPTH = TRILADHPH * (ANNFACSH + OPMAINTH)
C
C ANCOSUGSL = LO  ANNUAL TOTAL (CAP+O&M) COST OF UTES STORAGE ($TRIL/YR)
C ANCOSUGSM = MED ANNUAL TOTAL (CAP+O&M) COST OF UTES STORAGE ($TRIL/YR)
C ANCOSUGSH = HI  ANNUAL TOTAL (CAP+O&M) COST OF UTES STORAGE ($TRIL/YR)
C
      ANCOSUGSL = TRILUGSTL * (ANNFACSL + OPMAINTL)
      ANCOSUGSM = TRILUGSTM * (ANNFACSM + OPMAINTM)
      ANCOSUGSH = TRILUGSTH * (ANNFACSH + OPMAINTH)
C
C ANCOSHBTL = LO  ANNUAL TOTAL (CAP+O&M) COST OF BRICK HEAT BAT STORAGE ($TRIL/YR)
C ANCOSHBTM = MED ANNUAL TOTAL (CAP+O&M) COST OF BRICK HEAT BAT STORAGE ($TRIL/YR)
C ANCOSHBTH = HI  ANNUAL TOTAL (CAP+O&M) COST OF BRICK HEAT BAT STORAGE ($TRIL/YR)
C
      ANCOSHBTL = TRILHBTL * (ANNFACHBL + OPMAINTL)
      ANCOSHBTM = TRILHBTM * (ANNFACHBM + OPMAINTM)
      ANCOSHBTH = TRILHBTH * (ANNFACHBH + OPMAINTH)
C
C ANCOSSHPL = LOW  ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C ANCOSSHPM = MED  ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C ANCOSSHPH = HI   ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C TRILSHPL  = LOW CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILSHPM  = MED CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C TRILSHPH  = HI  CAPITAL COST HEAT PUMPS FOR HW/CW-STES+UTES
C ANFACHPL  = LO FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME HPLIFEL
C ANFACHPM  = MEAN FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C ANFACHPH  = HI FACTOR TO MULTIPLY CAPITAL HEAT PUMP COST BY TO GET ANNUAL COST
C
      ANCOSSHPL = TRILSHPL * (ANFACHPL + OPMAINTL)
      ANCOSSHPM = TRILSHPM * (ANFACHPM + OPMAINTM)
      ANCOSSHPH = TRILSHPH * (ANFACHPH + OPMAINTH)
C
C ANNCOSTL  = LOW AN COST ($TRIL/YR) ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C           + HEAT PUMPS TO FEED HW/CW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DIST
C             TRANSMISSION. FOR NEW+EXISTING
C ANNCOSTM  = MED AN COST ($TRIL/YR) ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C           + HEAT PUMPS TO FEED HW/CW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DIST
C             TRANSMISSION. FOR NEW+EXISTING
C ANNCOSTH  = HI  AN COST ($TRIL/YR) ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C           + HEAT PUMPS TO FEED HW/CW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DIST
C             TRANSMISSION. FOR NEW+EXISTING
C ANCOSPOWL = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWM = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWH = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSHTL  = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTM  = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTH  = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C
      ANNCOSTL = ANCOSPOWL + ANCOSHTL  + ANCOSBATL + ANCOSSTOL+ANCOSHPTL
     1         + ANCOSUGSL + ANCOSSHPL + ANCHTSTOL + ANCCLSTOL+ANCOSHBTL
      ANNCOSTM = ANCOSPOWM + ANCOSHTM  + ANCOSBATM + ANCOSSTOM+ANCOSHPTM
     1         + ANCOSUGSM + ANCOSSHPM + ANCHTSTOM + ANCCLSTOM+ANCOSHBTM
      ANNCOSTH = ANCOSPOWH + ANCOSHTH  + ANCOSBATH + ANCOSSTOH+ANCOSHPTH
     1         + ANCOSUGSH + ANCOSSHPH + ANCHTSTOH + ANCCLSTOH+ANCOSHBTH
C
C OMSTORL = LOW  O&M COST FOR STORAGE EACH YEAR ($TRIL/YEAR)
C OMSTORM = MEAN O&M COST FOR STORAGE EACH YEAR ($TRIL/YEAR)
C OMSTORH = HIGH O&M COST FOR STORAGE EACH YEAR ($TRIL/YEAR)
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C
      OMSTORL = OPMAINTL * (TRILBATL  + TRILSTORL + TRILHTSTL+TRILCLSTL
     1        + TRILADHPL + TRILUGSTL + TRILHBTL + TRILSHPL)
      OMSTORM = OPMAINTM * (TRILBATM  + TRILSTORM + TRILHTSTM+TRILCLSTM
     1        + TRILADHPM + TRILUGSTM + TRILHBTM + TRILSHPM)
      OMSTORH = OPMAINTH * (TRILBATH  + TRILSTORH + TRILHTSTH+TRILCLSTH
     1        + TRILADHPH + TRILUGSTH + TRILHBTH + TRILSHPH)
C
C CSPCHSTO  = MAX CHARGE RATE (TW) OF CSP STORAGE WHEN IT EXISTS.
C           = CSPCHARG - CSPDISCH
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C CSPCHARG  = MAX CHARGE RATE (TW) OF CSP DIRECT ELECTRICITY + STORAGE
C           = CSPDISCH + CSPCHSTO
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C             BASED ON SIZE OF MIRRORS (NOT SIZE OF GENERATOR)
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C           = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C
      WRITE(IOUT,166)
     1      (I, AVCAPLO(I)*1E6,AVCAPMN(I)*1E6,AVCAPHI(I)*1E6,I=1,MXCAP),
     1       0, CAPCSPLO  *1E6,CAPCSPMN  *1E6,CAPCSPHI  *1E6,
     1       0, AVLOCAPCST, AVMNCAPCST, AVHICAPCST,
     1       0, AVLOCAPHT,  AVMNCAPHT,  AVHICAPHT,
     1        CSPCHSTO, CSPCHARG, CSPDISCH, CSPCHARG/(CSPDISCH+SMAL30)
 166  FORMAT('CAP COST ($MIL/MW)         LOW         MEDIUM      HIGH',/
     1       'ONSHORE WIND         ',I2,3(0PF12.5),/
     1       'OFFSHORE WIND        ',I2,3(0PF12.5),/
     1       'RES ROOF PV          ',I2,3(0PF12.5),/
     1       'COMM/GOVT PV         ',I2,3(0PF12.5),/
     1       'UTILITY PV           ',I2,3(0PF12.5),/
     1       'CSP-WITH-STORAGE     ',I2,3(0PF12.5),/
     1       'CSP-NO-STORAGE       ',I2,3(0PF12.5),/
     1       'GEOTHERMAL ELEC      ',I2,3(0PF12.5),/
     1       'HYDROELECTRIC        ',I2,3(0PF12.5),/
     1       'TIDAL                ',I2,3(0PF12.5),/
     1       'WAVE                 ',I2,3(0PF12.5),/
     1       'SOLAR THERMAL        ',I2,3(0PF12.5),/
     1       'GEOTHERMAL HEAT      ',I2,3(0PF12.5),/
     1       'CSP-ACTUAL-STOR      ',I2,3(0PF12.5),/
     1       'AVG NEW ELEC CAPCOST ',I2,3(0PF12.5),/
     1       'AVG NEW HEAT CAPCOST ',I2,3(0PF12.5),//
     1       'CSP STORAGE CHARGE RATE (TW)      ',0PF12.5,/
     1       'CSP STORAGE+ELEC CHARGE RATE (TW) ',0PF12.5,/
     1       'CSP DISCHARGE RATE (TW)           ',0PF12.5,/
     1       'RATIO CSPCHARG/CSPDISCH           ',1(0PF12.5)/)
C
      WRITE(IOUT,168) (I,OANDMLO(I),OANDMMN(I),OANDMHI(I),I=1,MXCAP)
 168  FORMAT('O&M COST ($/KW/YR)  LOW         MEDIUM      HIGH',/
     1       'ONSHORE WIND     ',I2,3(0PF12.5),/
     1       'OFFSHORE WIND    ',I2,3(0PF12.5),/
     1       'RES ROOF PV      ',I2,3(0PF12.5),/
     1       'COMM/GOVT PV     ',I2,3(0PF12.5),/
     1       'UTILITY PV       ',I2,3(0PF12.5),/
     1       'CSP-WITH-STORAGE ',I2,3(0PF12.5),/
     1       'CSP-NO-STORAGE   ',I2,3(0PF12.5),/
     1       'GEOTHERMAL ELEC  ',I2,3(0PF12.5),/
     1       'HYDROELECTRIC    ',I2,3(0PF12.5),/
     1       'TIDAL            ',I2,3(0PF12.5),/
     1       'WAVE             ',I2,3(0PF12.5),/
     1       'SOLAR THERMAL    ',I2,3(0PF12.5),/
     1       'GEOTHERMAL HEAT  ',I2,3(0PF12.5),/)
C
      WRITE(IOUT,172) (I,YEARLIFEL(I),YEARLIFEM(I),YEARLIFEH(I),
     1                 I=1,MXCAP)
 172  FORMAT('LIFETIME (YEARS)       LOW         MEDIUM      HIGH',/
     1       'ONSHORE WIND     ',I2,3(0PF12.5),/
     1       'OFFSHORE WIND    ',I2,3(0PF12.5),/
     1       'RES ROOF PV      ',I2,3(0PF12.5),/
     1       'COMM/GOVT PV     ',I2,3(0PF12.5),/
     1       'UTILITY PV       ',I2,3(0PF12.5),/
     1       'CSP-WITH-STORAGE ',I2,3(0PF12.5),/
     1       'CSP-NO-STORAGE   ',I2,3(0PF12.5),/
     1       'GEOTHERMAL ELEC  ',I2,3(0PF12.5),/
     1       'HYDROELECTRIC    ',I2,3(0PF12.5),/
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     1       'TIDAL            ',I2,3(0PF12.5),/
     1       'WAVE             ',I2,3(0PF12.5),/
     1       'SOLAR THERMAL    ',I2,3(0PF12.5),/
     1       'GEOTHERMAL HEAT  ',I2,3(0PF12.5),/)
C
      WRITE(IOUT,174) TDLOSS*PCT,
     1  (I,TDLOSLO(I)*PCT,TDLOSMN(I)*PCT,TDLOSHI(I)*PCT,I=1,MXCAP)
 174  FORMAT('MEAN TRANSMIS & DISTRIBUTION LOSS (SHORT+LONG DIST) (%): ',
     1        0PF12.5,//,
     1       'T&D LOSS (%)        LOW         MEDIUM      HIGH',/
     1       'ONSHORE WIND     ',I2,3(0PF12.5),/
     1       'OFFSHORE WIND    ',I2,3(0PF12.5),/
     1       'RES ROOF PV      ',I2,3(0PF12.5),/
     1       'COMM/GOVT PV     ',I2,3(0PF12.5),/
     1       'UTILITY PV       ',I2,3(0PF12.5),/
     1       'CSP-WITH-STORAGE ',I2,3(0PF12.5),/
     1       'CSP-NO-STORAGE   ',I2,3(0PF12.5),/
     1       'GEOTHERMAL ELEC  ',I2,3(0PF12.5),/
     1       'HYDROELECTRIC    ',I2,3(0PF12.5),/
     1       'TIDAL            ',I2,3(0PF12.5),/
     1       'WAVE             ',I2,3(0PF12.5),/
     1       'SOLAR THERMAL    ',I2,3(0PF12.5),/
     1       'GEOTHERMAL HEAT  ',I2,3(0PF12.5),/)
C
      WRITE(IOUT,180)
     1     TRILLO,TRILHLO,TRILBATL,TRILSTORL,TRILHTSTL,TRILCLSTL,
     1      TRILADHPL,TRILUGSTL,TRILHBTL,TRILSHPL,TRILTOTL,AVLOCAPCST,
     1      AVLOCAPHT,
     1     TRILMN,TRILHMN,TRILBATM,TRILSTORM,TRILHTSTM,TRILCLSTM,
     1      TRILADHPM,TRILUGSTM,TRILHBTM,TRILSHPM,TRILTOTM,AVMNCAPCST,
     1      AVMNCAPHT,
     1     TRILHI,TRILHHI,TRILBATH,TRILSTORH,TRILHTSTH,TRILCLSTH,
     1      TRILADHPH,TRILUGSTH,TRILHBTH,TRILSHPH,TRILTOTH,AVHICAPCST,
     1      AVHICAPHT
 180  FORMAT('$TRILLION CAPITAL COST NEW DEVICES ',/
     1       '    ELEC-GENERATORS   HEAT-GENS   BAT-STOR    ELEC-STOR ',
     1       ' HEAT-STOR   COLD-STOR   HPTURBS     UG-STOR   BRICKSTOR',
     1       '   HEATPUMPS    ALL-CAP AVGELEC($MIL/MW) AVHEAT',/
     1       'LOW',4X,12(0PF12.5),/,
     1       'MED',4X,12(0PF12.5),/,
     1       'HI ',4X,12(0PF12.5),/)
C
C ANCOSHPTL = LOW  ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTM = MEAN ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTH = HIGH ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C
      WRITE(IOUT,181) OMSTORL,  OMSTORM,   OMSTORH,
     1                OMPOWL,   OMPOWM,    OMPOWH,
     1                OMHEATL,  OMHEATM,   OMHEATH,
     1                ANNCOSTL, ANNCOSTM,  ANNCOSTH,
     1                ANCOSPOWL,ANCOSPOWM, ANCOSPOWH,
     1                ANCOSHTL, ANCOSHTM,  ANCOSHTH,
     1                ANCOSBATL,ANCOSBATM, ANCOSBATH,
     1                ANCOSSTOL,ANCOSSTOM, ANCOSSTOH,
     1                ANCHTSTOL,ANCHTSTOM, ANCHTSTOH,
     1                ANCCLSTOL,ANCCLSTOM, ANCCLSTOH,
     1                ANCOSHPTL,ANCOSHPTM, ANCOSHPTH,
     1                ANCOSUGSL,ANCOSUGSM, ANCOSUGSH,
     1                ANCOSHBTL,ANCOSHBTM, ANCOSHBTH,
     1                ANCOSSHPL,ANCOSSHPM, ANCOSSHPH
 181  FORMAT('NEW WWS '/,
     1       'OMSTORL   OMSTORM   OMSTORH   ($TRIL) = ',3(0PF12.5)/,
     1       'OMPOWL    OMPOWM    OMPOWH    ($TRIL) = ',3(0PF12.5)/,
     1       'OMHEATL   OMHEATM   OMHEATH   ($TRIL) = ',3(0PF12.5)/,
     1       'ANNCOSTL  ANNCOSTM  ANNCOSTH  ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSPOWL ANCOSPOWM ANCOSPOWH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSHTL  ANCOSHTM  ANCOSHTH  ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSBATL ANCOSBATM ANCOSBATH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSSTOL ANCOSSTOM ANCOSSTOH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCHTSTOL ANCHTSTOM ANCHTSTOH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCCLSTOL ANCCLSTOM ANCCLSTOH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSHPTL ANCOSHPTM ANCOSHPTH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSUGSL ANCOSUGSM ANCOSUGSH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSHBTL ANCOSHBTM ANCOSHBTH ($TRIL) = ',3(0PF12.5)/,
     1       'ANCOSSHPL ANCOSSHPM ANCOSSHPH ($TRIL) = ',3(0PF12.5)/)
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C
      WRITE(IOUT,252) FACONWIN, FACOFFWIN, FACROOFPV,FACRESPV,FACCOMPV,
     1                FACUTILPV,CSPTURBFAC,CSPCHARFAC,FACSHT,INITYLOAD,
     1                IFINYLOAD,IBEGYLOAD
C
 252  FORMAT('FACONWIN  FACOFFWIN  FACROOFPV  = ',3(1X,0PF10.3)/,
     1       'FACRESPV  FACCOMPV   FACUTILPV  = ',3(1X,0PF10.3)/,
     1       'CSPTURBFAC CSPCHARFAC   FACSHT  = ',3(1X,0PF10.3)/,
     1       'INITYLOAD,IFINYLOAD, IBEGYLOAD  = ',3(1X,I10)/)
C
C STORHOURS = AVG NUMBER OF HOURS OF STORAGE AMONG ALL NON-UTES, NON-H2 STORAGE
C           = STORTWH / DISCHTW
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C UTESCHARG = MAX CHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             FROM EXCESS ELECTRIC POWER GENERATION
C             SINCE LOW-TEMP HEAT LOAD IN countrystats.dat ALREADY
C             CONVERTED TO EQUIVALENT ELECTRICAL LOAD ASSUMING
C             HEAT PUMPS WITH CPERFORM, UTESCCHARG IS REALLY THE CHARGE
C             RATE OF EQUIV ELECTRICITY TO GIVE HEATING FROM HEAT PUMPS
C UTESTWH   = TWH OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL OR WATER
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C UGFAC     = FACTOR TO MULTIPLY UTESCHARG BY TO INCREASE OR DECREASE
C             CHARGE RATE OF UTES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN GO ABOVE 1. HIGHER UGFAC-->MORE
C             EXPENSIVE COST OF HEAT PUMPS TO CHARGE STORAGE WITH
C             ELECTRICITY. IF UGFAC=0, THEN ONLY SOLAR COLLECTORS
C             (FACSHT) CAN SUPPLY UTES WITH HEAT .
C HWFAC     = FACTOR TO MULTIPLY HOTCHARGE BY TO INCREASE OR DECREASE
C             CHARGE RATE OF HW-STES STORAGE WITH ELECTRIC HEAT PUMPS.
C             IDEALLY 0-1 BUT CAN BE ABOVE 1.
C HCHARCSP  = MAX NUMBER HOURS THAT CSP CAN BE CHARGED FOR AT RATE CSPCHSTO
C             TO REACH FULL CAPACITY OF STORCTWH
C STORHCSP  = HOURS OF CSP STORAGE (HOURS TO DISCHARGE CSP STORAGE AT RATE
C             CSPDISCH WHEN STORAGE AT FULL CAPACITY)
C FLDISELEC = FRAC (DEFAULT 0.3) OF ALL END-USE ELECTRICITY SUBJECT TO HVDC LONG-DIST
C             TRANSMISSION (1200-2000 KM). FOR SMALL REGIONS (E.G., ISLANDS),
C             TRANSMISSION DISTANCES ARE SMALLER THUS FLDISELEC SHOULD
C             BE PROPORTIONATELY SMALLER
C H2ENERGY  = KWH/KG = TWH/TG TO PRODUCE 1 KG H2 FROM ELECTROLYSIS AND COMPRESS IT
C H2TANK    = MAX STORAGE (TG-H2) THAT H2 TANKS CAN HOLD AT GIVEN TIME
C COSTH2TK  = COST H2 TANK ($/KG) = 500.
C TANKCOST  = COST OF H2 TANK ($ BILLION)
C TGH2PYR   = TG-H2/YR PRODUCED FROM ELECTROLYSIS, COMPRESSED AND EITHER USED
C             IMMEDIATELY OR STORED
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C
      WRITE(IOUT,253) HCHARCSP,   CSPCHSTO,  STORCTWH,
     1                STORHCSP,   CSPDISCH,  STORCTWH,
     1                STORHPHS,   TSTORPHS,  STORPTWH,
     1                STORHCOLD,  TSTORCOOL, STOROTWH,
     1                STORHBAT,   BATDISCH,  STORBTWH,
     1                STORHHFC,   H2SDISCH,  STORFTWH,
     1                FCCHARG,    FCDISCH,
     1                STORHHBT,   HBTDISCH,  STOHBTWH,
     1                HBTCHARG,   HBTDISCH,
     1                STORHHWAT,  HOTDISCH,  STORHTWH,
     1                HOTCHARG,   CHARGTW,   STORTWH,
     1                STORHOURS,  DISCHTW,   STORTWH,
     1                STORUGHRS,  UTESDISCH, UTESTWH,
     1                STORUGDYS,  TWINUTES,  UTESCHARG,
     1                WARMMAX,    UGFAC,     MXHRDRM,
     1                H2STORMX,   HWFAC,     HPSIZE,
     1                DAYH2STOR,  TWHH2TOT,
     1                DAMCAPRAT,  HPTURBRAT,
     1                FLDISELEC,
     1                IFSTATES,   IFCANARY,  IMERGH2, IFHEATBAT
C
 253  FORMAT('HCHARCSP  CSPCHSTO   STORCTWH  = ',3(1X,0PF12.5)/,
     1       'STORHCSP  CSPDISCH   STORCTW   = ',3(1X,0PF12.5)/,
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     1       'STORHPHS  TSTORPHS   STORPTWH  = ',3(1X,0PF12.5)/,
     1       'STORHCOLD TSTORCOOL  STOROTWH  = ',3(1X,0PF12.5)/,
     1       'STORHBAT  BATDISCH   STORBTWH  = ',3(1X,0PF12.5)/,
     1       'STORHHFC  H2SDISCH   STORFTWH  = ',3(1X,0PF12.5)/,
     1       'FCCHARG   FCDISCH              = ',2(1X,0PF12.5)/,
     1       'STORHHBT  HBTDISCH   STOHBTWH  = ',3(1X,0PF12.5)/,
     1       'HBTCHARG  HBTDISCH             = ',2(1X,0PF12.5)/,
     1       'STORHHWAT HOTDISCH   STORHTWH  = ',3(1X,0PF12.5)/,
     1       'HOTCHARG  CHARGTW    STORTWH   = ',3(1X,0PF12.5)/,
     1       'STORHOURS DISCHTW    STORTWH   = ',3(1X,0PF12.5)/,
     1       'STORUGHRS UTESDISCH  UTESTWH   = ',3(1X,0PF12.5)/,
     1       'STORUGDYS TWINUTES   UTESCHARG = ',3(1X,0PF12.5)/,
     1       'WARMMAX-TW UGFAC     MXHRDRM   = ',2(1X,0PF12.5),1X,I12,/
     1       'H2STORMX-TWH HWFAC HPSIZE-TW   = ',3(1X,0PF12.5),/
     1       'DAYH2STOR (DAYS OF H2 STORAGE  = ',1(1X,0PF12.5),/
     1       'TWHH2TOT (TWH/YR ELEC FOR H2)  = ',1(1X,0PF12.5),/
     1       'DAMCAPRAT (YR)                 = ',1(1X,0PF12.5),/
     1       'HPTURBRAT (--)                 = ',1(1X,0PF12.5),/
     1       'FLDISELEC (--)                 = ',1(1X,0PF12.5),/
     1       'IFSTATES IFCANARY IMERGH2      = ',3(I13),/
     1       'IFHEATBAT                      = ',1(I13),/)
C
C ***************************************************************************
C     ESTIMATE DAILY HEATING AND COOLING LOADS FROM HEATING AND COOLING
C             DEGREE DATA AND ANNUAL HEATING AND COOLING LOADS
C ***************************************************************************
C INITYEAR = INITIAL YEAR OF SIMULATION
C KYEAR    = 1..NYEARS CURRENT YEAR OF SIMULATION, STARTING WITH INITYEAR
C MONCUM   = CUMULATIVE NUMBER OF DAYS OF SIMULATION IN INCREMENTS
C            OF DAYS PER MONTH. WHEN CURRENT I=1,NDSIM DAY EXCEEDS
C            MONCUM, ADVANCE MONTH NUMBER (KMON) TO NEXT MONTH BUT
C            START KMON BACK TO 1 AT BEGINNING OF NEW YEAR
C KMON     = 1..12 CURRENT MONTH OF SIMULATION
C KDAY     = 1..NDAYYR(KYEAR)=365 OR 366 DAY OF YEAR
C
      KDAY     = 0
      KMON     = 1
      KYEAR    = 1
      MONCUM   = LDMONTH(KYEAR,1)
      TCOOLSUM = 0.
      TWARMSUM = 0.
      TDRMSUM  = 0.
      TH2SUM   = 0.
      TALLSUM  = 0.
C
      WRITE(IOUT,175)
 175  FORMAT('GMTDAY  MON ALLFLEX-TW TCOOLDAY-TW TWARMDAY-TW ',
     1       'TLOADDRM-TW TLOADH2-TW')
C
C NDSIM    = TOTAL NUMBER OF DAYS OF MODEL SIMULATION HERE
C
      DO I     = 1, NDSIM
       KDAY    = KDAY + 1
C
C AT END OF ANY YEAR, REPEAT YEAR
C
       IF (I.GT.MONCUM) THEN
        KMON   = KMON + 1
        IF (KMON.EQ.13) THEN
         KDAY  = 1
         KMON  = 1
         KYEAR = KYEAR + 1
        ENDIF
        MONCUM = MONCUM + LDMONTH(KYEAR,KMON)
       ENDIF
C
C FRDAYCOOL = FRAC OF YEARLY AIR COOLING + REFRIG THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-COOLING DAYS ON DAY
C FRDAYWARM = FRAC OF YEARLY AIR & WATER HEATING THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-HEATING DAYS ON DAY
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C TCOOLDAY  = LOAD ON SPECIFIC DAY (TW) FOR COOLING (AC & REFRIG)
C TSTORAWH  = ANNUAL LOAD (TW) FOR AIR AND WATER HEATING SUBJECT TO STORAGE
C TWARMDAY  = LOAD ON SPECIFIC DAY OF YEAR (TW) FOR WARMING (AIR AND WATER)
```

```
C NDAYYR    = NUMBER OF DAYS PER YEAR OF SIMULATION (EITHER 365 OR 366)
C
       IF (IFCONUS.EQ.1) THEN
        TCOOLDAY(I) = TSTORCOOL * NDAYYR(KYEAR) * FRDAYCOOL(KYEAR,KMON)
        TWARMDAY(I) = TSTORAWH  * NDAYYR(KYEAR) * FRDAYWARM(KYEAR,KMON)
       ELSE
        TCOOLDAY(I) = TSTORCOOL * NDAYYR(KYEAR) * FRDAYCOOL(KYEAR,KDAY)
        TWARMDAY(I) = TSTORAWH  * NDAYYR(KYEAR) * FRDAYWARM(KYEAR,KDAY)
       ENDIF
C
C DAYFLEX   = FLEX LOAD (TW) FROM DEMAND-RESPONSE EACH GMT DAY OF YEAR
C             DOES NOT INCLUDE COOLING LOAD, HEATING LOAD OR LOAD FOR
C             H2 PRODUCTION.
C H2FLEX    = FLEX LOAD (TW) FOR NON-GRID H2 PROD/COMPRESS/STORAGE. H2 LOAD FOR
C             TRANSPORT/INDUSTRY IS ASSUMED CONSTANT DURING YEAR
C TLOADDRM  = ANNUAL LOAD (TW) SUBJECT TO DEMAND-RESPONSE MANAGEMENT
C TLOADFLEX = TOTAL FLEXIBLE LOAD (TW) CONUS 2050 WITH WWS
C             INCLUDES LOADS SUBJECT TO STORAGE, DEMAND-RESPONSE, AND H2 PROD
C TFLEXEVS  = FLEXIBLE TRANSPORTATION LOAD FOR ELECTRIC VEHICLES (TW)
C             THE REST OF FLEXIBLE TRANSPORT LOAD IS FOR H2FC VEHICLES
C
       DAYFLEX( I) = TLOADDRM
       H2FLEX(  I) = TLOADH2
C
C TCOOLSUM = SUM OF SPECIFIC DAY COOLING LOAD MULTIPLIED BY HRSPDAY (TWH/DAY)
C TWARMSUM = SUM OF SPECIFIC DAY HEATING LOAD MULTIPLIED BY HRSPDAY (TWH/DAY)
C TDRMSUM  = SUM OF SPECIFIC DAY DRM LOAD MULTIPLIED BY HRSPDAY (TWH/DAY)
C TH2SUM   = SUM OF SPECIFIC DAY H2 LOAD MULTIPLIED BY HRSPDAY (TWH/DAY)
C TALLSUM  = SUM OF SPECIFIC DAY DRM+COOL+HEAT+LOAD MULT BY HRSPDAY (TWH/DAY)
C HRSPDAY  = NUMBER OF HOURS PER DAY (24)
C
       TCOOLSUM = TCOOLSUM + TCOOLDAY(I) * HRSPDAY
       TWARMSUM = TWARMSUM + TWARMDAY(I) * HRSPDAY
       TDRMSUM  = TDRMSUM  + TLOADDRM    * HRSPDAY
       TH2SUM   = TH2SUM   + H2FLEX(  I) * HRSPDAY
       TALLSUM  = TALLSUM  + (TCOOLDAY(I) + TWARMDAY(I)
     1                     +  DAYFLEX( I) + H2FLEX(  I)) * HRSPDAY
C
       WRITE(IOUT,176) I,KMON,TCOOLDAY(I) + TWARMDAY(I)
     1                    + DAYFLEX( I) + H2FLEX(  I),
     1                 TCOOLDAY(I),TWARMDAY(I),DAYFLEX(I),H2FLEX(I)
 176   FORMAT('X ',I5,1X,I2,5(1PE12.5))
      ENDDO
C     ENDDO I = 1, NDSIM
C
C TAVCOOL = AVERAGE COOLING LOAD (TW) OVER SIMULATION
C TAVWARM = AVERAGE HEATING LOAD (TW) OVER SIMULATION
C NHRSIM   = TOTAL NUMBER OF HOURS OF MODEL SIMULATION HERE
C
      TAVCOOL  = TCOOLSUM / NHRSIM
      TAVWARM  = TWARMSUM / NHRSIM
C
      WRITE(IOUT,177) TALLSUM/NHRSIM,TAVCOOL,TAVWARM,TDRMSUM/NHRSIM,
     1                TH2SUM /NHRSIM
      WRITE(IOUT,177) TLOADFLEX, TSTORCOOL,TSTORAWH, TLOADDRM, TLOADH2
 177  FORMAT('X AVG YR',5(1PE12.5))
      WRITE(IOUT,*)
C
C ***************************************************************************
C    READ AND PROCESS 2030 8760 HOURLY LOAD DATA FOR 94 COUNTRIES/GROUPS OF
C        COUNTRIES REPRESENTING WOLRD LOAD PLUS WORLD GRAND TOTAL FROM
C                         loadreg.COUNTRY2030GW
C ***************************************************************************
C DATA: http://neocarbonenergy.fi/internetofenergy/  PAPERS BY C. BREYER ET AL
C ***************************************************************************
C READLOAD  = 2030 LOAD (GW) FOR EACH 1..8760 HOUR FOR CURRENT COUNTRY FROM
C             loadreg.COUNTRY2030GW FILE
C NLOADCOUN = NUMBER OF COUNTRIES READ FROM FILE loadreg.COUNTRY2030GW
C
      IF (GRIDLOAD.EQ.'COUNTRY2030GW') THEN
       OPEN(KLOD, FILE = PATHLOAD//'loadreg.COUNTRY2030GW')
C
       NLOADCOUN = 0
C
       READ(KLOD,*)
```

```
       READ(KLOD,*)
       READ(KLOD,*)
 237   READ(KLOD,*,END=239) DUMMY, (READLOAD(I),I=1,8760)
C
       NLOADCOUN = NLOADCOUN + 1
C
       IF (NLOADCOUN.GT.MXCOUNTRY) THEN
        WRITE(IOUT,*)'POWERWORLD: NLOADCOUN>MXCOUNTRY ',
     1                            NLOADCOUN,MXCOUNTRY
        STOP
       ENDIF

C ***************************************************************************
C FILL 24 HOURS FOR FEB 29 (HOURS 1417..1440) SINCE DATA READ FOR  NON-LEAP YEAR
C ***************************************************************************
C NAMELOAD  = NAME OF EACH 1..NLOADCOUN COUNTRIES
C STORLOAD  = 2030 LOAD (TW) FOR EACH 1..MXHPYEAR HOUR IN EACH 1..NLOADCOUN
C             COUNTRY FROM loadreg.COUNTRY2030GW FILE
C AVGLOAD   = AVERAGE ANNUAL LOAD (TW) BY COUNTRY OR REGION
C             IN loadreg.COUNTRY2030GW
C
       NAMELOAD(NLOADCOUN) = DUMMY
C
       AVGLOAD = 0.
       DO J      = 1, 8760
        AVGLOAD  = AVGLOAD + READLOAD(J) * TWPERGW
       ENDDO
       AVGLOAD   = AVGLOAD / 8760.
       WRITE(IOUT,246) NLOADCOUN, DUMMY, AVGLOAD
 246   FORMAT('# LOADNAM LOAD-TW= ',I3,1X,A16,0PF10.6)
C
C THIS ENSURES THAT ON LEAP DAYS AND THE FOLLOWING DAY, THE LOAD IS SAME
C
       DO J  = 1, MXHPYEAR
        IF (J.LE.1416) THEN
         STORLOAD(NLOADCOUN,J) = READLOAD(J) * TWPERGW
        ELSE
         STORLOAD(NLOADCOUN,J) = READLOAD(J-24) * TWPERGW
        ENDIF
       ENDDO
C
C ***************************************************************************
C ASSIGN A LOAD PROFILE TO EACH COUNTRY FROM THE 2010-2014 OR 2013 RAW
C HOURLY LOAD DATASETS. FOR THE FOLLOWING GRID REGIONS THAT ARE ON THEIR
C OWN, ASSIGN LOAD PROFILES FROM A NEARBY COUNTRY:
C
C TAIWAN                   - ASSIGN FROM CHINA
C CUBA                     - ASSIGN FROM EITHER MEXICO, CENTRAL AM OR VENEZUELA
C HAITI-DOMINICAN REPUBLIC - ASSIGN FROM EITHER MEXICO, CENTRAL A OR VENEZUELA
C JAMAICA                  - ASSIGN FROM EITHER MEXICO, CENTRAL AM OR VENEZUELA
C
C FOR COUNTRIES WITH NO DATA THAT ARE IN GRID REGIONS WITH DATA, ASSUME
C LOAD PROFILE IS THE SAME AS THE SUMMED PROFILES OF ALL OTHER COUNTRIES
C IN GRID REGION WITH DATA:
C
C TRINIDAD AND TOBAGO, DUTCH ANTILLES, URUGUAY IN THE SOUTH AMERICA REGION
C HONG KONG IN THE CHINA REGION
C
C ***************************************************************************
C          MAP EACH 1..NCOUNTRY COUNTRY TO EACH 1..NLOADCOUN LOAD FILE
C ***************************************************************************
C ILOADCOUN = 1..NLOADCOUN COUNTRY OR REGION WITH LOAD DATA FROM
C             loadreg.COUNTRY2030GW FILE FOR EACH 1..NCOUNTRY COUNTRY
C             THIS ARRAY NEEDS TO BE FILLED EVEN IF OBTAINING LOAD DATA
C             FROM loadreg.XXX
C NAMEORIG  = NAME OF 1..NCOUNTRY AS READ FROM countrystats.dat
C             THIS NAME IS CHANGED BELOW TO MATCH THOSE FROM wwssupworld.dat
C DUMMY     = NAME OF COUNTRY FROM COUNTRY LOAD FILE
C
C
       DO IC           = 1, NCOUNTRY
        COUNTRY        = NAMEORIG(IC)
        IF (DUMMY.EQ.COUNTRY) THEN
         ILOADCOUN(IC) = NLOADCOUN
        ELSEIF (DUMMY.EQ.'ARGENTINA'.AND.
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1         (COUNTRY.EQ.'ARGENTINA'.OR.COUNTRY.EQ.'URUGUAY')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Angola-Namibia'.AND.
1         (COUNTRY.EQ.'ANGOLA'.OR.
1          COUNTRY.EQ.'BOTSWANA'.OR.COUNTRY.EQ.'NAMIBIA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Armenia-Azerba'.AND.
1         (COUNTRY.EQ.'ARMENIA'.OR.
1          COUNTRY.EQ.'AZERBAIJAN'.OR.COUNTRY.EQ.'GEORGIA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Austria-Hungar'.AND.
1        (COUNTRY.EQ.'AUSTRIA'.OR.COUNTRY.EQ.'HUNGARY')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Bahrain+Qatar'.AND.
1         (COUNTRY.EQ.'BAHRAIN'.OR.COUNTRY.EQ.'QATAR')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Belgium-Nether'.AND.
1        (COUNTRY.EQ.'BELGIUM'.OR.
1         COUNTRY.EQ.'NETHERLANDS'.OR.COUNTRY.EQ.'LUXEMBOURG'))THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Bolivia-Paragu'.AND.
1         (COUNTRY.EQ.'BOLIVIA'.OR.COUNTRY.EQ.'PARAGUAY')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'BurkinaFaso-Be'.AND.
1        (COUNTRY.EQ.'BURKINA-FASO'.OR.COUNTRY.EQ.'BENIN'
1     .OR.COUNTRY.EQ.'TOGO'.OR.COUNTRY.EQ.'GHANA'
1     .OR.COUNTRY.EQ.'IVORY-COAST')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'MEXICO'.AND.
1         (COUNTRY.EQ.'JAMAICA'.OR.COUNTRY.EQ.'HAITI'
1      .OR.COUNTRY.EQ.'CUBA'.OR.COUNTRY.EQ.'DOMINICAN-REPU')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Central-Americ'.AND.
1         (COUNTRY.EQ.'BELIZE'.OR.COUNTRY.EQ.'COSTA-RICA'
1      .OR.COUNTRY.EQ.'EL-SALVADOR'.OR.COUNTRY.EQ.'GUATEMALA'
1      .OR.COUNTRY.EQ.'HONDURAS'.OR.COUNTRY.EQ.'NICARAGUA'
1      .OR.COUNTRY.EQ.'PANAMA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'CentralAfrican'.AND.
1         (COUNTRY.EQ.'CENT-AFRICAN-R'.OR.COUNTRY.EQ.'CAMEROON'
1      .OR.COUNTRY.EQ.'CONGO'.OR.COUNTRY.EQ.'GABON'
1      .OR.COUNTRY.EQ.'EQUATORIAL-GUI')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'CHINA'.AND.
1         (COUNTRY.EQ.'CHINA'.OR.COUNTRY.EQ.'HONG-KONG'
1      .OR.COUNTRY.EQ.'TAIWAN')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'CzechRep-Slova'.AND.
1       (COUNTRY.EQ.'CZECH-REPUBLIC'.OR.COUNTRY.EQ.'SLOVAKIA'))THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Estonia-Latvia'.AND.
1         (COUNTRY.EQ.'ESTONIA'.OR.COUNTRY.EQ.'LATVIA'
1      .OR.COUNTRY.EQ.'LITHUANIA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Ireland-UK-Isl'.AND.
1         (COUNTRY.EQ.'IRELAND'.OR.COUNTRY.EQ.'UNITED-KINGDOM'
1      .OR.COUNTRY.EQ.'ISLE-OF-MAN'.OR.COUNTRY.EQ.'GUERNSEY'
1      .OR.COUNTRY.EQ.'JERSEY')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Italy-SanMarin'.AND.
1         (COUNTRY.EQ.'ITALY'.OR.COUNTRY.EQ.'SAN-MARINO'
1      .OR.COUNTRY.EQ.'VATICAN'.OR.COUNTRY.EQ.'MALTA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Jordan+West-Ba'.AND.
1         (COUNTRY.EQ.'JORDAN'.OR.COUNTRY.EQ.'WEST-BANK'
1      .OR.COUNTRY.EQ.'GAZA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Kenya-Uganda'.AND.
1         (COUNTRY.EQ.'KENYA'.OR.COUNTRY.EQ.'UGANDA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Kyrgyzstan-Taj'.AND.
1         (COUNTRY.EQ.'KYRGYZ-REPUBLI'.OR.COUNTRY.EQ.'TAJIKISTAN'))
1          THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'LAOS'.AND.
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1         (COUNTRY.EQ.'LAO-PDR')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Malaysia-West-'.AND.
1         (COUNTRY.EQ.'SINGAPORE')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Malaysia-East-'.AND.
1       (COUNTRY.EQ.'MALAYSIA'.OR.COUNTRY.EQ.'BRUNEI-DARUSSA'))THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'MOROCCO'.AND.
1       (COUNTRY.EQ.'MOROCCO-(INC-W'.OR.
1        COUNTRY.EQ.'GRAN-CANARIA'.OR.COUNTRY.EQ.'LANZAROTE-FV'.OR.
1        COUNTRY.EQ.'TENERIFE'    .OR.COUNTRY.EQ.'LA-PALMA'.OR.
1        COUNTRY.EQ.'LA-GOMERA'   .OR.COUNTRY.EQ.'EL-HIERRO'.OR.
1        COUNTRY.EQ.'LANZ-FV-CSP')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Nepal+Bhutan'.AND.
1         (COUNTRY.EQ.'NEPAL'.OR.COUNTRY.EQ.'BHUTAN')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'New-Guinea-Pap'.AND.
1         (COUNTRY.EQ.'NEW-GUINEA')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Niger-Chad'.AND.
1         (COUNTRY.EQ.'NIGER'.OR.COUNTRY.EQ.'CHAD')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Portugal-Spain'.AND.
1         (COUNTRY.EQ.'PORTUGAL'.OR.COUNTRY.EQ.'SPAIN'
1       .OR.COUNTRY.EQ.'GIBRALTAR')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Romania-Bulgar'.AND.
1         (COUNTRY.EQ.'ROMANIA'.OR.COUNTRY.EQ.'BULGARIA'
1       .OR.COUNTRY.EQ.'GREECE')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Slovenia-Croat'.AND.
1         (COUNTRY.EQ.'SLOVENIA'.OR.COUNTRY.EQ.'CROATIA'
1       .OR.COUNTRY.EQ.'BOSNIA-HERZEGO'.OR.COUNTRY.EQ.'SERBIA'
1       .OR.COUNTRY.EQ.'MONTENEGRO'.OR.COUNTRY.EQ.'MACEDONIA'
1       .OR.COUNTRY.EQ.'ALBANIA'.OR.COUNTRY.EQ.'KOSOVO')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Somalia-Djibou'.AND.
1         (COUNTRY.EQ.'SOMALIA'.OR.COUNTRY.EQ.'DJIBOUTI')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'SouthAfrica-Le'.AND.
1         (COUNTRY.EQ.'SOUTH-AFRICA'.OR.COUNTRY.EQ.'LESOTHO'
1       .OR.COUNTRY.EQ.'SWAZILAND'
1       .OR.COUNTRY.EQ.'ESWATINI-KINGD')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Sudan-Eritrea'.AND.
1         (COUNTRY.EQ.'SUDAN'.OR.COUNTRY.EQ.'ERITREA'.OR.
1          COUNTRY.EQ.'SOUTH-SUDAN')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Switzerland-Li'.AND.
1         (COUNTRY.EQ.'SWITZERLAND'.OR.COUNTRY.EQ.'LIECHTENSTEIN'))
1         THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Tanzania-Rwand'.AND.
1         (COUNTRY.EQ.'TANZANIA'.OR.COUNTRY.EQ.'RWANDA'
1       .OR.COUNTRY.EQ.'BURUNDI')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Turkey-Cyprus'.AND.
1         (COUNTRY.EQ.'TURKEY'.OR.COUNTRY.EQ.'CYPRUS')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Ukraine-Moldov'.AND.
1        (COUNTRY.EQ.'UKRAINE'.OR.COUNTRY.EQ.'MOLDOVA-REPUBL'))THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'Venezuela-Guya'.AND.
1         (COUNTRY.EQ.'VENEZUELA'.OR.COUNTRY.EQ.'GUYANA'
1       .OR.COUNTRY.EQ.'FRENCH-GUIANA'.OR.COUNTRY.EQ.'SURINAME'
1       .OR.COUNTRY.EQ.'TRINIDAD-AND-T'
1       .OR.COUNTRY.EQ.'CURACAO')) THEN
     ILOADCOUN(IC) = NLOADCOUN
    ELSEIF (DUMMY.EQ.'WestSahara-Mau'.AND.
1         (COUNTRY.EQ.'WEST-SAHARA'.OR.COUNTRY.EQ.'MAURITANIA'
1       .OR.COUNTRY.EQ.'MALI'.OR.COUNTRY.EQ.'SENEGAL'
1       .OR.COUNTRY.EQ.'GAMBIA'.OR.COUNTRY.EQ.'GUINEA-BISSAU'
1       .OR.COUNTRY.EQ.'SIERRA-LEONE'.OR.COUNTRY.EQ.'LIBERIA')) THEN
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         ILOADCOUN(IC) = NLOADCOUN
        ELSEIF (DUMMY.EQ.'Zambia-Zimbabw'.AND.
     1         (COUNTRY.EQ.'ZAMBIA'    .OR.COUNTRY.EQ.'ZIMBABWE'
     1      .OR.COUNTRY.EQ.'MOZAMBIQUE'.OR.COUNTRY.EQ.'MALAWI'
     1      .OR.COUNTRY.EQ.'MAURITIUS'
     1      .OR.COUNTRY.EQ.'MADAGASCAR')) THEN
         ILOADCOUN(IC) = NLOADCOUN
        ENDIF
       ENDDO
C      ENDDO IC = 1, NCOUNTRY
C
       GOTO 237
 239   CLOSE(KLOD)
C
C ILOADCOUN = 1..NLOADCOUN COUNTRY OR REGION WITH LOAD DATA FROM
C             loadreg.COUNTRY2030GW FILE FOR EACH 1..NCOUNTRY COUNTRY
C NAMELOAD  = NAME OF EACH 1..NLOADCOUN COUNTRIES
C NLOADCOUN = NUMBER OF COUNTRIES READ FROM FILE loadreg.COUNTRY2030GW
C
       WRITE(IOUT,*)
       DO IC = 1, NCOUNTRY
        IF (ILOADCOUN(IC).EQ.0) THEN
         WRITE(IOUT,*)'POWERWORLD: ILOADCOUN=0'
         WRITE(IOUT,244) IC, NAMEORIG(IC), ILOADCOUN(IC),'NO VALUE'
         STOP
        ELSE
         WRITE(IOUT,244) IC, NAMEORIG(IC), ILOADCOUN(IC),
     1                   NAMELOAD(ILOADCOUN(IC))
        ENDIF
       ENDDO
C
 244   FORMAT('# COUNTRY LOAD# LOADNAM= ',I3,1X,A16,I3,1X,A16)
C
C ***************************************************************************
C  SUM LOAD DATA OVER ALL COUNTRIES IN GRID REGION FOR EACH HOUR AND FOR YEAR
C ***************************************************************************
C ALOADHR   = HOURLY LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD HOUR IN EACH
C             IY=1, 11 YEAR, CORRESPONDING TO 2006 TO 2016, RESPECTIVELY.
C             ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C             HOURS 1417..1440 = 0.
C             HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1 OF YEAR IY
C YRLOAD    = ANNUAL AVERAGE LOAD (TW) FOR EACH 1..MXYLOAD YEAR ((2006 TO 2016)
C             FOR ELECTRICITY-ONLY LOAD DATA READ IN
C IYLOFLOAD = YEAR (2006 TO 2016) CORRESPONDING TO EACH J=1,MXYLOAD INDEX #
C NAMORIGGR = ORIG NAME OF EACH 1..NCOUNGRID COUNTRY OF EACH 1..NUMGRIDS REGION
C NUMCOUNGR = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C ILOADCOUN = 1..NLOADCOUN COUNTRY OR REGION WITH LOAD DATA FROM
C             loadreg.COUNTRY2030GW FILE FOR EACH 1..NCOUNTRY COUNTRY
C STORLOAD  = 2030 LOAD (TW) FOR EACH 1..MXHPYEAR HOUR IN EACH 1..NLOADCOUN
C
       WRITE(IOUT,251)
 251   FORMAT(/'GRID           # COUN# NAMCOUNTRY    LOAD#  NAMLOAD ')
C
       DO I        = 1, NCOUNGRID(IGRIDUSE)
        IC         = NUMCOUNGR(IGRIDUSE,I)
        NLOADCOUN  = ILOADCOUN(IC)
        WRITE(IOUT,247) NAMEGRID(IGRIDUSE), I, IC, NAMECOUN(IC),
     1                  NLOADCOUN, NAMELOAD(NLOADCOUN)
       ENDDO
 247   FORMAT(A14,I3,I4,1X,A14,I4,1X,A14)
C
       WRITE(IOUT,*)
       WRITE(IOUT,*) 'LOAD DATA FROM loadreg.COUNTRY2030GW'
C
       DO IY            = 1, MXYLOAD
        YRLOAD(IY)      = 0.
        DO I            = 1, MXHPYEAR
         DO J           = 1, MXCOUNTRY
          IFUSED(  J,I) = 0
         ENDDO
        ENDDO
C
        LOADYR       = IYOFLOAD(IY)
C
```

```
C ALOADHR = 0 ONLY FOR FEB. 29 IN NON-LEAP YEARS
C
        NUMHRS       = 0.
        DO ILOAD     = 1, MXHPYEAR
         IF (MOD(LOADYR,4).EQ.0.OR.ILOAD.LT.1417.OR.ILOAD.GT.1440) THEN
          NUMHRS      = NUMHRS + 1
          DO I        = 1, NCOUNGRID(IGRIDUSE)
           IC         = NUMCOUNGR(IGRIDUSE,I)
           NLOADCOUN  = ILOADCOUN(IC)
C
C ***************************************************************************
C SUM 2030 LOADS AMONG ALL COUNTRIES IN GRID REGION. DON'T WEIGHT HOURLY LOADS
C YET BY 2050 TO CURRENT ANNUAL LOAD RATIO. THIS IS DONE LATER.
C ***************************************************************************
C IFUSED   = 0 IF LOAD DATA HAS NOT YET BEEN ADDED TO ALOADHR FOR A GIVEN
C            LOAD REGION IN THE CURRENT YEAR
C          = 1 IF IT HAS.
C            MAKE SURE LOAD REGIONS THAT INCLUDE MULTIPLE COUNTRIES ARE ADDED
C            ONLY ONCE TO REGIONAL LOAD HERE, SINCE OTHERWISE, FOR EXAMPLE, LOADS
C            FOR THE SUM OF 3 COUNTRIES IN THE REGION CAN BE ADDED 3 TIMES,
C            RESULTING IN 3X MORE LOAD FROM THESE COUNTRIES FOR THE REGION THAN
C            IN REALITY.
C STORLOAD = 2030 LOAD (TW) FOR EACH 1..MXHPYEAR HOUR IN EACH 1..NLOADCOUN
C            COUNTRY FROM loadreg.COUNTRY2030GW FILE
C
          IF (IFUSED(NLOADCOUN,ILOAD).EQ.0) THEN
           ALOADHR(ILOAD,IY)=ALOADHR(ILOAD,IY)+STORLOAD(NLOADCOUN,ILOAD)
           YRLOAD(       IY)=YRLOAD(       IY)+STORLOAD(NLOADCOUN,ILOAD)
           IFUSED(NLOADCOUN,ILOAD) = 1
          ENDIF

          ENDDO
         ENDIF
        ENDDO
C       ENDDO ILOAD=1, MXHPYEAR
C
        YRLOAD(IY)   = YRLOAD(IY) / NUMHRS
        WRITE(IOUT,248) IY,LOADYR,YRLOAD(IY),NUMHRS
       ENDDO
C      ENDDO IY = 1, MXYLOAD
C
 248   FORMAT('#  YR AVLOAD-TW TSTEPS/YR= ',I2,1X,I4,0PF10.6,I9)
C
C ***************************************************************************
C    READ HOURLY LOAD DATA 2016-2019 FOR 13 CONUS REGIONS AND ENTIRE CONUS
C   https://www.eia.gov/beta/electricity/gridmonitor/dashboard/custom/pending
C ***************************************************************************
C LOADREG   = 2016-19 LOAD (MWh/h=MW) FOR EACH 1..14 REGIONS IN THE CONTINENTAL
C             US AND CONUS AS A WHOLE
C             VALUES (MWh/h) ARE FOR THE PREVIOUS HOUR (THUS IF IHGMT=5,
C             VALUES ARE FOR BETWEEN HOURS 4 AND 5
C DAYGMT    = GMT DAY SINCE BEGINNING OF 2016 = IHGMT / 24.
C           = 0 INDICATES DATA ARE FOR LAST HOUR OF 2015 IN GRENWICH
C           = 0.041666667 INDICATES DATA FOR FIRST HOUR 2016 IN GREENWICH
C IHGMT     = IHEST + 5 = HOUR IN GREENWICH CORRESPONDING TO IHEST
C IHEST     = EASTERN STANDARD TIME END-HOUR OF DATA SINCE BEGINNING OF 2016
C           = 0 INDICATES DATA ARE FOR 11PM-12AM LAST DAY OF 2015 IN US EAST COAST
C           = -5 INDICATES DATA ARE FOR 6PM-7PM LAST DAY OF 2015 IN US EAST COAST
C
      ELSEIF (GRIDLOAD.EQ.'CONUS2016-19') THEN
C
C REGIONS FOR WHICH LOAD DATA AVAILABLE (DIFFERENT FROM NERC REGIONS)
C REGION   REG NAME      STATES IN REGION
C 1. CAL   California:   California
C 2. CAR   Carolinas:    North Carolina, South Carolina
C 3. CENT  Central:      Kansas, Nebraska, North Dakota, Oklahoma, South Dakota,
C 4. FLA   Florida:      Florida
C 5. MIDA  Mid-Atlantic: Delaware, Kentucky, Maryland, New Jersey, Ohio,
C                        Pennsylvania, Virginia, Washington D.C., West Virginia
C 6. MIDW  Midwest:      Arkansas, Illinois, Indiana, Iowa, Louisiana, Michigan,
C                        Minnesota, Missouri, Wisconsin
C 7. NE    New England:  Connecticut, Maine, Massachusetts, New
C                        Hampshire, Rhode Island, Vermont
C 8. NW    Northwest:    Colorado, Idaho, Montana, Nevada, Oregon, Utah,
C                        Washington State, Wyoming
```

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C 9. NY    New York:     New York
C 10.SE    Southeast:    Alabama, Georgia, Mississippi
C 11.SW    Southwest:    Arizona, New Mexico
C 12.TEN   Tennessee:    Tennessee
C 13.TEX   Texas:        Texas
C 14.CONUS ContinentalUS:48 CONUS STATES+DC
C
       JCAL   = 1
       JCAR   = 2
       JCENT  = 3
       JFLA   = 4
       JMIDA  = 5
       JMIDW  = 6
       JNEAST = 7
       JNWEST = 8
       JNYORK = 9
       JSEAST = 10
       JSWEST = 11
       JTEN   = 12
       JTEX   = 13
       JCONUS = 14
C
       OPEN(KLOD, FILE = PATHLOAD//'loadreg.CONUS2016-19')
C
       DO I = 1, 10
        READ(KLOD,*)
       ENDDO
C
C SKIP 1ST LINE OF DATA (IHGMT=0) SINCE WANT TO START 1ST HOUR 2016 GMT TIME
C
       READ(KLOD,*)
 240   READ(KLOD,*,END=241) DAYGMT,IHGMT,IHEST,(USALOAD(IHGMT,I),I=1,14)
       GOTO 240
C
 241   CONTINUE
C
C ***************************************************************************
C          ASSIGN LOAD PROFILE FOR GRID REGION. THIS WILL BE SCALED
C            BY ACTUAL 2050 WWS INFLEXIBLE LOAD LATER ON, SO
C          MAGNITUDE NOT IMPORTANT HERE, ONLY TIME-SERIES PROFILE
C ***************************************************************************
C TOTLD   = HOURLY LOAD (MWh/h=MW) IN GRID REGION FOR EACH LOAD HOUR
C           IN EACH IY=1, 4 YEAR, CORRESPONDING TO 2016 TO 2019, RESPECTIVELY.
C           ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C           HOURS 1417..1440 = 0.
C           HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1 OF YEAR IY
C IY2016  = 1
C IY2019  = 4

       IG                  = 0
       DO IY               = IY2016, IY2019
        YRLOAD(IY)         = 0.
        LOADYR             = IYOFLOAD(IY)
C
C ALOADHR = 0 ONLY FOR FEB. 29 IN NON-LEAP YEARS
C IHGMT   = IHEST + 5 = HOUR IN GREENWICH CORRESPONDING TO IHEST
C IHEST   = EASTERN STANDARD TIME END-HOUR OF DATA SINCE BEGINNING OF 2016
C         = 0 INDICATES DATA ARE FOR 11PM-12AM LAST DAY OF 2015 IN US EAST COAST
C         = -5 INDICATES DATA ARE FOR 6PM-7PM LAST DAY OF 2015 IN US EAST COAST
C
        NUMHRS             = 0
        DO ILOAD           = 1, MXHPYEAR
         IF (MOD(LOADYR,4).EQ.0.OR.ILOAD.LT.1417.OR.ILOAD.GT.1440) THEN
          IG               = IG     + 1
          NUMHRS           = NUMHRS + 1
C
C ***************************************************************************
C              NORTH AMERICAN RELIABILITY CORPORATION (NERC) REGIONS
C ***************************************************************************
C WECC  = WESTERN ELECTRICITY COORDINATING COUNCIL
C         Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon,
C         Utah, Washington State, Wyoming
C MRO   = MIDWEST RELIABILITY ORGANIZATION
C         Iowa, Kansas, Minnesota, Nebraska, North Dakota, Oklahoma, South Dakota,
C         Wisconsin
```

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C TRE   = TEXAS RELIABILITY ENTITY
C         Texas
C RFC   = RELIABILITY FIRST CORPORATION
C         Delaware, Indiana, Maryland, Michigan, New Jersey, Ohio, Pennsylvania,
C         Washington D.C., West Virginia
C SERC  = SOUTHEASTERN ELECTRIC RELIABILITY COUNCIL
C         Alabama, Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi,
C         Missouri, North Carolina, South Carolina, Tennessee, Virginia
C NPCC  = NORTHEAST POWER COORDINATING COUNCIL
C         Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont
C ASCC  = ALASKA SYSTEM COORDINATING COUNCIL
C         Alaska
C HICC  = HAWAIIAN ISLANDS COORDINATING COUNCIL
C         Hawaii
C CALI  = CALIFORNIA ALONE
C FLA   = FLORIDA ALONE
C NEWY  = NEW YORK STATE ALONE
C USCON = 48 US STATES + DC
C
C PARTITION REGIONAL LOADS FROM LOAD REGIONS TO NERC REGIONS. FRACTIONS ARE THE NUMBER
C OF STATES IN THE NERC REGION OVERLAPPLING THE LOAD REGION DIVIDED
C BY THE NUMBER OF STATES IN THE LOAD REGION
C THE TOTAL LOAD AMONG ALL NERC REGIONS EQUALS THE CONUS LOAD (JCONUS)
C LOADNAME = NAME OF LOAD REGION(S) (USED FOR PRINTING ONLY)
C
          IF (GRIDUSE.EQ.'WECC') THEN
           TOTLD=USALOAD(IG,JCAL)+USALOAD(IG,JNWEST)+USALOAD(IG,JSWEST)
           LOADNAME = 'CAL-NW-SW'
          ELSEIF (GRIDUSE.EQ.'MRO') THEN
           TOTLD=(3./9.)*USALOAD(IG,JMIDW)+USALOAD(IG,JCENT)
           LOADNAME = 'MIDW-CENT'
          ELSEIF (GRIDUSE.EQ.'TRE') THEN
           TOTLD=USALOAD(IG,JTEX)
           LOADNAME = 'TEX'
          ELSEIF (GRIDUSE.EQ.'RFC') THEN
           TOTLD=(2./9.)*USALOAD(IG,JMIDW)+(7./9.)*USALOAD(IG,JMIDA)
           LOADNAME = 'MIDW-MIDA'
          ELSEIF (GRIDUSE.EQ.'SERC') THEN
           TOTLD=USALOAD(IG,JCAR)+USALOAD(IG,JSEAST)+USALOAD(IG,JTEN)
     1          +USALOAD(IG,JFLA)
     1          +(4./9.)*USALOAD(IG,JMIDW)+(2./9.)*USALOAD(IG,JMIDA)
           LOADNAME = 'CARSETNFLMWMA'
          ELSEIF (GRIDUSE.EQ.'NPCC') THEN
           TOTLD=USALOAD(IG,JNEAST)+USALOAD(IG,JNYORK)
           LOADNAME = 'NE-NY'
          ELSEIF (GRIDUSE.EQ.'ASCC') THEN
           TOTLD=USALOAD(IG,JNWEST)
           LOADNAME = 'NW'
          ELSEIF (GRIDUSE.EQ.'HICC') THEN
           TOTLD=USALOAD(IG,JCAL)
           LOADNAME = 'CAL'
          ELSEIF (GRIDUSE.EQ.'CALI') THEN
           TOTLD=USALOAD(IG,JCAL)
           LOADNAME = 'CAL'
          ELSEIF (GRIDUSE.EQ.'FLA') THEN
           TOTLD=USALOAD(IG,JFLA)
           LOADNAME = 'FLA'
          ELSEIF (GRIDUSE.EQ.'NEWY') THEN
           TOTLD=USALOAD(IG,JNYORK)
           LOADNAME = 'NY'
          ELSEIF (GRIDUSE.EQ.'TXMRO') THEN
           TOTLD=(3./9.)*USALOAD(IG,JMIDW)+USALOAD(IG,JCENT)
     1          +        USALOAD(IG,JTEX)
           LOADNAME = 'TEX-MW-CENT'
          ELSEIF (GRIDUSE.EQ.'USCON') THEN
           TOTLD=USALOAD(IG,JCONUS)
           LOADNAME = 'CONUS'
          ENDIF
C
C TOTLD   = HOURLY LOAD (MWh/h=MW) IN GRID REGION FOR EACH LOAD HOUR
C ALOADHR = HOURLY LOAD (TWh/h=TW) IN GRID REGION FOR EACH LOAD HOUR
C YRLOAD  = ANNUAL AVERAGE LOAD (TW) FOR EACH 1..4 YEAR (2016 TO 2019)
C           FOR ELECTRICITY-ONLY LOAD DATA READ IN
C TWPERMW = TW PER MW (=0.000001)
C
```

```
          ALOADHR(ILOAD,IY) = TOTLD * TWPERMW
          YRLOAD(       IY) = YRLOAD(IY) + ALOADHR(ILOAD,IY)
         ENDIF
        ENDDO
C       ENDDO ILOAD=1, MXHPYEAR
C
        YRLOAD(IY)   = YRLOAD(IY) / NUMHRS
        WRITE(IOUT,248) IY,LOADYR,YRLOAD(IY),NUMHRS
       ENDDO
C      ENDDO IY = 1, MXYLOAD
C
       WRITE(IOUT,268)
 268   FORMAT(/'GRID          # STAT# NAMESTATE     NAMLOAD ')
C
       DO I        = 1, NCOUNGRID(IGRIDUSE)
        IC         = NUMCOUNGR(IGRIDUSE,I)
        WRITE(IOUT,269) NAMEGRID(IGRIDUSE), I, IC, NAMECOUN(IC),
     1                  LOADNAME
       ENDDO
 269   FORMAT(A14,I3,I4,1X,A14,1X,A14)
C
       WRITE(IOUT,*)
       WRITE(IOUT,*) 'LOAD DATA FROM loadreg.CONUS2016-19'
C
      ENDIF
C     ENDIF GRIDLOAD.EQ.'COUNTRY2030GW' OR 'CONUS2016-19'
C
      WRITE(IOUT,*)
C
C ***************************************************************************
C READ/PROCESS 2006-2016 HOURLY LOAD DATA FOR INDIVIDUAL COUNTRIES/REGIONS FROM
C                             loadreg.XXX
C ***************************************************************************
C        DATA FROM ENTSO-E https://www.entsoe.eu/Pages/default.aspx
C        https://www.entsoe.eu/db-query/country-packages/production-
C        consumption-exchange-package
C ***************************************************************************
C GRIDLOAD    = NAME OF LOAD DATA COUNTRY OR REGION USED FOR GRIDUSE REGION.
C               GRIDLOAD = 'COUNTRY2030GW' -> DATA FROM loadreg.COUNTRY2030GW
C               GRIDLOAD = 'CONUS2016-19' -> DATA FROM loadreg.CONUS2016-19
C               GRIDLOAD = 'XXX' (WHERE XXX IS ANY COUNTRY NAME)
C               GRIDLOAD = 'CONUS' --> DATA FROM loadreg.CONUS
C               GRIDLOAD = GRIDUSE -> DATA FROM loadreg.XXX
C               IF GRIDLOAD = 'XXX' THEN HOURLY LOAD WILL BE SCALED TO HOURLY
C                FROM COUNTRY'S DATA. IF GRIDLOAD='CONUS' THEN IT WILL BE SCALED
C                FROM CONUS DATA.
C               IF GRIDLOAD = GRIDUSE OR GRIDLOAD = 'COUNTRY2030GW' THEN
C                SUM LOADS FOR GRID REGION OVER ALL COUNTRIES IN REGION
C                FOR WHICH FILES AVAILABLE. FOR EXAMPLE, IF GRIDLOAD='EUROPE',
C                SUM OVER ALL COUNTRIES IN EUROPE FOR WHICH DATA ARE AVAILABLE. IF
C                DATA ARE NOT AVAILABLE FOR A COUNTRY IN THE REGION, THAT IS OKAY,
C                SINCE DATA FOR THE OTHER COUNTRIES ARE STILL SUMMED, AND FINAL
C                LOAD IS SCALED BY TAKING THE PRODUCT OF 2050 REGIONAL INFLEX LOAD
C                X (CURRENT HOURLY LOAD / TOTAL YEARLY LOAD OVER ALL HOURS FOR
C                DATA THAT ARE AVAILABLE)
C loadreg.xxx = CONTAINS LOAD DATA FOR 1 OR MORE YEARS FOR ELECTRIC POWER
C               SECTOR AT 1 HOUR RESOLUTION FOR GRID REGION
C               xxx = EITHER 'GRIDUSE', WHICH CONSISTS OF LOAD ALREADY
C                     SUMMED FOR A REGION, OR
C               xxx = 'CONUS' WHICH ARE THE 48 CONTIGUOUS U.S. STATES
C                     AND CONTAINS 2006 AND 2007 LOAD DATA FOR ELECTRIC SECTOR
C               xxx = SPECIFIC COUNTRY THAT LOAD DATA ARE SCALED FROM.
C NLOADFILE   = NUMBER OF HOURLY LOAD DATA FILES TO READ & SUM OVER GRID REGION
C             = 0 FOR U.S. STATES (IFSTATES=1) & 143 COUNTRIES OUTSIDE EUROPE
C NCOUNGRID   = NUMBER OF COUNTRIES IN EACH 1..NUMGRIDS GRID REGION
C
C IF GRIDLOAD='COUNTRY2030GW' THEN LOAD TAKEN CARE OF IN loadreg.COUNTRY2030GW
C IF GRIDLOAD='CONUS2016-19' THEN LOAD TAKEN CARE OF IN loadreg.CONUS2016-19
C
      IF (GRIDLOAD.EQ.'COUNTRY2030GW'.OR.GRIDLOAD.EQ.'CONUS2016-19')THEN
       NLOADFILE = 0
      ELSEIF (GRIDLOAD.EQ.GRIDUSE) THEN
       NLOADFILE = NCOUNGRID(IGRIDUSE)
      ELSE
       NLOADFILE = 1
```

```
      ENDIF
C
      IF (NLOADFILE.GT.0) THEN
       DO I            = 1, MXHPYEAR
        DO J           = 1, MXYLOAD
         ALOADHR( I,J) = 0.
        ENDDO
       ENDDO
      ENDIF
C
C ***************************************************************************
C        READING ONLY COUNTRY FILES FOR EUROPE OR CONUS HERE 2006-2016
C ***************************************************************************
C ALOADREG  = HOURLY LOAD DATA (TW) FOR 365 OR 366 DAYS OF YEAR
C ILOAD     = COUNTS NUMBER OF HOURS OF LOAD DATA = 365x24=8760 OR 366x24=8784
C FRACYR    = FRACTION OF YEAR CORRESPONDING TO DATA. EACH FRACTION
C             CORRESPONDS TO ONE HOUR CURRENTLY.
C LOADYR    = YEAR OF LOAD DATA FOR GLOBAL GRID REGIONS (IFCONUS=0)
C NDYLOAD   = NUMBER OF DAYS PER YEAR IN YEAR OF LOAD DATA (365 OR 366) (IFCONUS=0)
C NAMORIGGR = ORIG NAME OF EACH 1..NCOUNGRID COUNTRY OF EACH 1..NUMGRIDS REGION
C NUMCOUNGR = 1..NCOUNTRY COUNTRY NUMBER OF EACH 1..NCOUNGRID COUNTRY
C             OF EACH 1..NUMGRIDS REGION
C NLOADFILE = NUMBER OF HOURLY LOAD DATA FILES TO READ & SUM OVER GRID REGION
C           = 0 FOR U.S. STATES (IFSTATES=1) & 143 COUNTRIES OUTSIDE EUROPE
C
      DO 127 NC    = 1, NLOADFILE
C
       IF (GRIDLOAD.EQ.GRIDUSE) THEN
        OPEN(KLOD, FILE = PATHLOAD//'loadreg.'//NAMORIGGR(IGRIDUSE,NC))
       ELSE
        OPEN(KLOD, FILE = PATHLOAD//'loadreg.'//GRIDLOAD)
       ENDIF
C
C ***************************************************************************
C              COUNTRY DATA SUMMED OVER ALL COUNTRIES IN A REGION HERE
C ***************************************************************************
C ILOAD    = 1..8784 HOURS OF A YEAR, INCLUDING LEAP-DAY HOURS, REGARDLESS OF
C            WHETHER IT IS A LEAP YEAR OR NOT. NON-LEAP YEARS ARE ADJUSTED FOR
C            SUBSEQUENTLY.
C ALOADHR  = HOURLY LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD HOUR IN EACH
C            IY=1, 11 YEAR, CORRESPONDING TO 2006 TO 2016, RESPECTIVELY.
C            ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C            HOURS 1417..1440 = 0.
C ILOADMW  = HOURLY LOAD (MW) IN EACH COUNTRY BY IY=1, 11 YEAR (2006-2016)
C            FOR GIVEN HOUR
C MXYLOAD  = MAX NUMBER OF YEARS OF LOAD DATA (11 = 2006 TO 2016) IN FILES
C TWPERMW  = 0.000001 TERAWATTS (TW) PER MEGAWATT (MW)
C MXHPYEAR = NUMBER OF HOURS PER YEAR FOR LEAP YEARS = 8784
C MXHPDAY  = NUMBER OF HOURS PER DAY (24)
C
       IF (GRIDLOAD.EQ.GRIDUSE.OR.IFHRLOAD.EQ.1) THEN
C
C IF FILE HAS NO DATA (E.G., FOR SOME COUNTRIES IN GRID REGION), GO TO NEXT
C
        READ(KLOD,*,END=139)
        READ(KLOD,*)
        READ(KLOD,*)
        READ(KLOD,*)
C
C IFHRLOAD  = 1: HI-RESOLUTION (30-SECOND) LOAD DATA
C           = 0: 1-HOUR RESOLUTION LOAD DATA
C
        IF (IFHRLOAD.EQ.0) THEN
         DO ILOAD      = 1, MXHPYEAR
          DO IY        = 1, MXYLOAD
           ILOADMW(IY) = 0
          ENDDO
C
          READ(KLOD,*) DUMMY,KLOAD,(ILOADMW(IY),IY=1,MXYLOAD)
C
C SUM ALOADHR OVER ALL COUNTRIES IN GRID REGION FOR EACH HOUR & YEAR
C
          DO IY              = 1, MXYLOAD
           ALOADHR(ILOAD,IY) = ALOADHR(ILOAD,IY) + ILOADMW(IY) * TWPERMW
          ENDDO
```

```
C
          IF (KLOAD.NE.ILOAD) THEN
           WRITE(IOUT,*) 'POWERWORLD: ILOAD.NE.KLOAD IN ',
     1                   NAMORIGGR(IGRIDUSE,NC),ILOAD, KLOAD,
     1                   DUMMY,(ILOADMW(IY),IY=1,MXYLOAD)
           STOP
          ENDIF
C
         ENDDO
C        ENDDO ILOAD
C
C ***************************************************************************
C                   READ HIGH TIME RESOLUTION LOAD DATAA
C ***************************************************************************
C TWPERMW   = 0.000001 TERAWATTS (TW) PER MEGAWATT (MW)
C MXTSPYR   = MAX NUMBER OF 30-SECOND TIME STEPS PER YEAR
C             FOR LEAP YEARS, IT IS 1,054,080 = 8784 HRS/YRx120 30-S/HR
C MXYHRLOAD = MAX NUMBER OF YEARS OF HI-RES LOAD DATA IN FILE
C BLOADMW   = LOAD (MW) READ IN EACH TIME STEP
C HRESLOAD  = 30-S LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD INTERVAL
C             DURING EACH IY YEAR
C             ILOAD = 1..1054080 30-S INTERVAL OF YEAR. FOR NON-LEAP YEARS VALUES FOR
C             HOURS 1417..1440 = 0.
C I1,..I5   = MONTH, DAY, HOUR, MINUTE, SECOND OF LOAD DATA
C BTIME     = GMT DAY OF YEAR AS A FRACTION (0 = 0 GMT JAN 1), ALWAYS
C             FROM 0.00 TO 366.00 REGARDLESS OF WHETHER A LEAP YEAR
C TIMWWS    = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C
        ELSE
C       ELSEIF IFHRLOAD=1
C
         DO ILOAD      = 1, MXTSPYR
          DO IY        = 1, MXYHRLOAD
           BLOADMW(IY) = 0
          ENDDO
C
          READ(KLOD,*) I1,I2,I3,I4,I5,BTIME,
     1                 (BLOADMW(IY),IY=1,MXYHRLOAD)
C
C SUM HRLOAD OVER ALL COUNTRIES IN GRID REGION FOR EACH TIME INTERVAL & YEAR
C
          DO IY               = 1, MXYHRLOAD
           HRESLOAD(ILOAD,IY) = HRESLOAD(ILOAD,IY)+BLOADMW(IY)*TWPERMW
          ENDDO
C
         ENDDO
C        ENDDO ILOAD
C
        ENDIF
C       ENDIF IFHRLOAD=0 OR 1
C
C ***************************************************************************
C                   2006 AND 2007 HOURLY CONUS DATA
C ***************************************************************************
C IY2006  = 1..MXYLOAD YEAR CORRESPONDING TO 2006 (1..MXYLOAD = 2006 TO 2016)
C IY2007  = 1..MXYLOAD YEAR CORRESPONDING TO 2007 (1..MXYLOAD = 2006 TO 2016)
C ATIME   = LOAD DATA GMT DAY OF YEAR (0 = 0 GMT JANUARY 1) ALWAYS FROM
C           0.00 TO 366.00 REGARDLESS OF WHETHER A LEAP YEAR
C ALOAD06 = 2006 HOURLY LOAD DATA (TW) FOR 365 DAYS OF YEAR
C           HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1, 2006
C ALOAD07 = 2007 HOURLY LOAD DATA (TW) FOR 365 DAYS OF YEAR
C           HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1, 2007
C ALOADHR = HOURLY LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD HOUR IN EACH
C           IY=1, 11 YEAR, CORRESPONDING TO 2006 TO 2016, RESPECTIVELY.
C           ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C           HOURS 1417..1440 = 0.
C           HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1 OF YEAR IY
C
       ELSEIF (GRIDLOAD.EQ.'CONUS') THEN
C
        DO I = 1, 8
         READ(KLOD,*)
        ENDDO
C
        ILOAD = 0
```

```
 125    READ(KLOD,*,END=139) ATIMEX, ALOAD06X, ALOAD07X
C
        ILOAD          = ILOAD + 1
C
C SKIP 24 HOURS FOR FEB 29 (HOURS 1417..1440) SINCE 2006 & 2007 NON-LEAP YEARS
C
        IF (ILOAD.EQ.1417) THEN
         ILOAD  = 1441
        ENDIF
C
C ATIMEX = LOAD DATA GMT DAY OF YEAR (0 = 0 GMT JANUARY 1) ALWAYS FROM
C          0.00 TO 366.00 REGARDLESS OF WHETHER A LEAP YEAR
C
        IF (ILOAD.GE.1417) THEN
         ATIMEX = ATIMEX + 1.0
        ENDIF
C
        IF (ILOAD.GT.MXLOAD) THEN
         WRITE(IOUT,*)'POWERWORLD: ILOAD>MXLOAD ',ILOAD,MXLOAD
         STOP
        ENDIF
C
        ALOADHR(ILOAD,IY2006) = ALOAD06X
        ALOADHR(ILOAD,IY2007) = ALOAD07X
        GOTO 125
C
C ***************************************************************************
C       INDIVIDUAL COUNTRY OR ALREADY-SUMMED REGIONAL DATA FOR ONE YEAR
C                         E.G. loadreg.ALL-AFRICA
C ***************************************************************************
C
       ELSE
C      ELSEIF GRIDLOAD.NE.GRIDUSE.AND.GRIDLOAD.NE.'CONUS'
C
        DO I = 1, 6
         READ(KLOD,*)
        ENDDO
        READ(KLOD,*) LOADYR
        READ(KLOD,*)
C
C MXYLOAD = MAX NUMBER OF YEARS OF LOAD DATA (11 = 2006 TO 2016) IN FILES
C LOADYR  = ACTUAL YEAR OF LOAD DATA (2006 TO 2016)
C IYLOAD  = 1..MXYLOAD YEAR OF LOAD DATA (MXYLOAD = 11: 2006 TO 2016)
C
        IYLOAD  = LOADYR - IYBEFORE
C
        IF (IYLOAD.LE.0.OR.IYLOAD.GT.MXYLOAD) THEN
         WRITE(IOUT,*)'POWERWORLD: IYLOAD OUT BOUNDS ',IYLOAD,MXYLOAD
         STOP
        ENDIF
C
        IF (MOD(LOADYR,4).EQ.0) THEN
         NDYLOAD = 366
        ELSE
         NDYLOAD = 365
        ENDIF
C
        ILOAD = 0
C
 126    READ(KLOD,*,END=139) FRACYR, ALOADREGX
        ILOAD          = ILOAD + 1
C
C FOR NON-LEAP YEARS, SKIP 24 HOURS FOR FEB 29 (HOURS 1417..1440)
C
        IF (NDYLOAD.EQ.365.AND.ILOAD.EQ.1417) THEN
         ILOAD  = 1441
        ENDIF
C
        IF (ILOAD.GT.MXLOAD) THEN
         WRITE(IOUT,*)'POWERWORLD: ILOAD>MXLOAD ',ILOAD,MXLOAD
         STOP
        ENDIF
C
        ALOADHR(ILOAD,IYLOAD)  = ALOADREGX
        GOTO 126
```

```
      ENDIF
C     ENDIF NLOADFLE > 1
C
 139  CLOSE(KLOD)
C
 127  CONTINUE
C     CONTINUE NC = 1, NLOADFILE
C
C ***************************************************************************
C SUM LOAD DATA OVER YEAR FOR GRID REGION THEN FIND ANNUAL AVERAGE LOAD EACH YEAR
C ***************************************************************************
C ALOADHR   = HOURLY LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD HOUR IN EACH
C             IY=1, 11 YEAR, CORRESPONDING TO 2006 TO 2016, RESPECTIVELY.
C             ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C             HOURS 1417..1440 = 0.
C             HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1 OF YEAR IY
C YRLOAD    = ANNUAL AVERAGE LOAD (TW) FOR EACH 1..MXYLOAD YEAR ((2006 TO 2016)
C IYLOFLOAD = YEAR (2006 TO 2016) CORRESPONDING TO EACH J=1,MXYLOAD INDEX #
C
      IF (NLOADFILE.GT.0) THEN
       WRITE(IOUT,*) 'LOAD DATA FROM loadreg.XXX FILES'
C
C IFHRLOAD  = 1: HI-RESOLUTION (30-SECOND) LOAD DATA
C           = 0: 1-HOUR RESOLUTION LOAD DATA
C
      IF (IFHRLOAD.EQ.0) THEN
C
        DO IY         = 1, MXYLOAD
         YRLOAD(IY)   = 0.
         NUMHRS       = 0.
         LOADYR       = IYOFLOAD(IY)
C
C ALOADHR = 0 ONLY FOR FEB. 29 IN NON-LEAP YEARS
C
         DO ILOAD     = 1, MXHPYEAR
          IF (MOD(LOADYR,4).EQ.0.OR.ILOAD.LT.1417.OR.ILOAD.GT.1440) THEN
           YRLOAD(IY) = YRLOAD(IY) + ALOADHR(ILOAD,IY)
           NUMHRS     = NUMHRS + 1
C
C ***************************************************************************
C FOR NON-LEAP YEAR LOAD DATA WITH NO LOAD VALUES FEB 29 (HOURS 1417..1440,
C SET LOAD VALUES FOR FEB 29 FROM SAME HOUR OF PREVIOUS DAY IN CASE NEED
C NO USE NON-LEAP YEAR LOAD DATA FOR LEAP YEAR SIMULATION.A
C ***************************************************************************
C
          ELSE
           ALOADHR(ILOAD,IY) = ALOADHR(ILOAD-MXHPDAY,IY)
          ENDIF
         ENDDO
C
         YRLOAD(IY)   = YRLOAD(IY) / NUMHRS
         WRITE(IOUT,248) IY,LOADYR,YRLOAD(IY),NUMHRS
        ENDDO
C       ENDDO IY = 1, MXYLOAD
C
C ***************************************************************************
C            FIND AVERAGE LOAD WITH HIGH-RESOLUTION LOAD DATA
C ***************************************************************************
C
      ELSE
C     ELSEIF IFHRLOAD=1
C
C NTSPERHR = 120 = NUMBER OF 30-SECOND TIMES STEPS PER HR
C HRESLOAD = 30-S LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD INTERVAL
C            DURING EACH IY YEAR
C            ILOAD = 1..1054080 30-S INTERVAL OF YEAR. FOR NON-LEAP YEARS VALUES FOR
C            HOURS 1417..1440 = 0.
C YLOADHR  = ANN AVG LOAD (TW) FOR EACH 1..MXYHRLOAD YEAR, HIGH-RES LOAD
C
        DO IY        = 1, MXYHRLOAD
         YLOADHR(IY) = 0.
         NUMSTEP     = 0
         LOADYR      = IYOFHRLD(IY)
C
         DO ILOAD      = 1, MXTSPYR
```

```
C
          IF (MOD(LOADYR,4).EQ.0.OR.ILOAD.LE.1416*NTSPERHR.OR.
     1                              ILOAD.GT.1440*NTSPERHR) THEN
           YLOADHR(IY) = YLOADHR(IY) + HRESLOAD(ILOAD,IY)
           NUMSTEP     = NUMSTEP + 1
C
C ***************************************************************************
C FOR NON-LEAP YEAR LOAD DATA WITH NO LOAD VALUES FEB 29
C (30-S INTERVALS 1416*120+1..1440*120,
C SET LOAD VALUES FOR FEB 29 FROM SAME TIME STEP OF PREVIOUS DAY IN CASE NEED
C NO USE NON-LEAP YEAR LOAD DATA FOR LEAP YEAR SIMULATION.A
C ***************************************************************************
C
          ELSE
           HRESLOAD(ILOAD,IY) = HRESLOAD(ILOAD-MXHPDAY*NTSPERHR,IY)
          ENDIF
         ENDDO
C
         YLOADHR(IY)   = YLOADHR(IY) / NUMSTEP
         WRITE(IOUT,248) IY,LOADYR,YLOADHR(IY),NUMSTEP
        ENDDO
C       ENDDO IY = 1, MXYHRLOAD
C
       ENDIF
C      ENDIF IFHRLOAD = 0 OR 1
       WRITE(IOUT,*)
C
      ENDIF
C     ENDIF NLOADFILE>0
C
C ***************************************************************************
C SCALE HOURLY LOAD FOR GRID REGION BY RATIO OF 2050 INFLEXIBLE LOAD TO TOTAL
C                         ANNUAL LOAD FROM DATA FILE
C ***************************************************************************
C BLOAD     = CURRENT HOUR NON-COLD, NOT HOT INFLEX LOAD (TW) ACROSS ALL SECTORS
C DLOAD     = 2050 30-SECOND INFLEXIBLE LOAD DATA (TW) FOR GRID REGION FROM LOAD DATA
C             EXTRAPOLATED TO 2050
C TLOADINFX = EXTIMATED INFLEXIBLE LOAD IN 2050 WITH WWS (TW)
C INITYLOAD = INITIAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED.
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2006 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IFINYLOAD = FINAL YEAR (2006-2016 CURRENTLY) OF LOAD DATA USED
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C           = 2007 AND IFCONUS=1 OR GRIDLOAD='CONUS'
C           = 2008 FOR GRIDLOAD='AFRICA" SINCE THAT IS YEAR DATA FOR
C IBEGYLOAD = YEAR BETWEEN AND INCLUSIVE OF INITYLOAD AND IFINYLOAD
C             THAT LOAD DATA STARTS. SO, FOR EXAMPLE, IF
C             IF ONLY 1 YEAR OF LOAD DATA --> INITYLOAD=IFINYLOAD=IBEGYLOAD
C             SUPPOSE INITYLOAD = 2006 AND IFINYLOAD=2007 AND NYEARS=6
C             AND IBEGYLOAD = 2007, THEN LOAD DATA USED IN THE FOLLOWING ORDER:
C             2007 2006 2007 2006 2007 2006 .
C             SUPPOSE INITYLOAD = 2013 AND IFINYLOAD=2015 AND NYEARS=6
C             AND IBEGYLOAD=2013 THEN ORDER IS: 2013 2014 2015 2013 2014
C MXHPDAY   = NUMBER OF HOURS PER DAY
C NHYEAR    = NUMBER OF HOURS PER YEAR OF SIMULATION (EITHER 8760 OR 8784)
C NHYCUM    = CUMULATIVE NUMBER OF HOURS OF SIMULATION PRIOR TO JAN 1 0 GMT
C             OF CURRENT I=1,NYEARS YEAR
C ILOAD     = COUNTS NUMBER OF HOURS OF LOAD DATA = 365x24=8760 OR 366x24=8784
C ALOADHR   = HOURLY LOAD (TW) IN EACH GRID REGION FOR EACH ILOAD HOUR IN EACH
C             IY=1, 11 YEAR, CORRESPONDING TO 2006 TO 2016, RESPECTIVELY.
C             ILOAD = 1.8784 HOURS OF YEAR, SO FOR NON-LEAP YEARS VALUES FOR
C             HOURS 1417..1440 = 0.
C             HOUR 1 DATA ARE FOR 0-1 GMT ON JANUARY 1 OF YEAR IY
C YRLOAD    = ANNUAL AVERAGE LOAD (TW) FOR EACH 1..MXYLOAD YEAR ((2006 TO 2016)
C MXYLOAD   = MAX NUMBER OF YEARS OF LOAD DATA (11 = 2006 TO 2016) IN FILES
C LOADYR    = ACTUAL YEAR OF LOAD DATA (2006 TO 2016)
C IYLOAD    = 1..MXYLOAD YEAR OF LOAD DATA (MXYLOAD = 11: 2006 TO 2016)
C             FOR CURRENT I=1, NYEARS YEAR OF SIMULATION
C MXHPYEAR  = NUMBER OF HOURS PER YEAR FOR LEAP YEARS = 8784
C AHRSIM    = CURRENT GMT HOUR OF SIM CORRESPONDING TO LOAD DATA VALUE
C             (0.5 = 0-1 GMT JAN 1)
C TIMLOAD   = GMT HOUR OF SIMULATION (0.5 = 0-1 GMT JANUARY 1) CORRESPONDING TO
C             TIME OF LOAD DATA. VARIES FROM 1..NHRSIM
C NHRSIM    = TOTAL NUMBER OF HOURS OF MODEL SIMULATION HERE
```

```
C
      LOADYR       = IBEGYLOAD - 1
      AHRSIM       = -0.5
      J            = 0
      SUMINFHL     = 0.
      SUMINFCL     = 0.
C
      WRITE(IOUT,128)
 128  FORMAT('YR LOADYR HRSIM   HRYR  MXLD-TW TIMX-HR MNLD-TW TIMIN ',
     1       'RAMPMX-TW/H TIMRMP LDRATIO TNONHC-TW YRLOAD-TW')
C
      DO I          = 1, NYEARS
       LOADYR       = LOADYR + 1
C
       IF (LOADYR.GT.IFINYLOAD) THEN
        LOADYR      = INITYLOAD
       ENDIF
C
       IYLOAD       = LOADYR - IYBEFORE
C
       KHOUR        = 0
       DO M         = 1, MXHPYEAR
C
C SKIP LEAP DAY FOR NON LEAP YEARS
C HOURS 1417-1440 OF A YEAR CORRESPOND TO FEBRUARY 29 (LEAP DAY)`
C
C KDAY     = 1..NDAYYR DAY OF YEAR (1..365 NONLEAP YEARS, 1..366 LEAP YEARS)
C KHOUR    = 1..8760 HOURS OF YEAR FOR NON-LEAP YEARS; 1..8784 FOR LEAP YEARS
C MXHPDAY  = NUMBER OF HOURS PER DAY (24)
C MXHPYEAR = NUMBER OF HOURS PER YEAR FOR LEAP YEARS = 8784
C
        IF (NHYEAR(I).EQ.MXHPYEAR.OR.M.LT.1417.OR.M.GT.1440) THEN
         J           = J     + 1
         KHOUR       = KHOUR + 1
         KDAY        = 1 + (KHOUR-1)/MXHPDAY
         AHRSIM      = AHRSIM   + 1.
C
C BLOAD     = 2050 HOURLY NON-COLD, NOT HOT INFLEX LOAD (TW) ACROSS ALL SECTORS
C             EXTRAPOLATED FROM CURRENT TO 2050
C DLOAD     = 2050 30-SECOND INFLEXIBLE, NON-COLD, NON-HOT LOAD DATA (TW) ACROSS
C             ALL ENERGY SECTORS FOR GRID REGION FROM LOAD DATA
C TNONHC    = ANNUAL AVG TOTAL INFLEXIBLE LOAD (TW) THAT IS NOT HOT OR COLD LOAD
C HOTHOUR   = CURRENT HOUR TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C COLDHOUR  = CURRENT HOUR TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C ELECHOT   = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
C ELECCOLD  = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C FRDAYWARM = FRAC OF YEARLY AIR & WATER HEATING THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-HEATING DAYS ON DAY
C FRDAYCOOL = FRAC OF YEARLY AIR COOLING + REFRIG THAT OCCURS ON CURRENT GMT DAY
C             DETERMINED FROM NUMBER OF DEGREE-COOLING DAYS ON DAY
C NTSPERHR  = 120 = NUMBER OF 30-SECOND TIMES STEPS PER HR
C YLOADHR   = ANN AVG LOAD (TW) FOR EACH 1..MXYHRLOAD YEAR, HIGH-RES LOAD
C
         IF (IFHRLOAD.EQ.0) THEN
          BLOAD(J)    = TNONHC   * ALOADHR(M,IYLOAD) / YRLOAD(IYLOAD)
         ELSE
          LJ          = (J - 1) * NTSPERHR
          MJ          = (M - 1) * NTSPERHR
          DO LH       = 1, NTSPERHR
           LJ         = LJ + 1
           MJ         = MJ + 1
           DLOAD(LJ)  = TNONHC*HRESLOAD(MJ,IYLOAD)/YLOADHR(IYLOAD)
          ENDDO
         ENDIF
C
         IF (IFGATHEAT.NE.1) THEN
          HOTHOUR( J) = ELECHOT  * NDAYYR(I) * FRDAYWARM(I,KDAY)
          COLDHOUR(J) = ELECCOLD * NDAYYR(I) * FRDAYCOOL(I,KDAY)
          SUMINFHL    = SUMINFHL + HOTHOUR( J)
          SUMINFCL    = SUMINFCL + COLDHOUR(J)
         ENDIF
C
        ENDIF
C       ENDIF NHYEAR(I).EQ.MXHPYEAR...
C
```

```
       ENDDO
C      ENDDO M = 1, MXYPYEAR
C
      ENDDO
C     ENDDO I = 1, NYEARS
C
C AVINFHL = AVERAGE INFLEXIBLE HEAT LOAD (TW) OVER SIMULATION
C AVINFCL = AVERAGE INFLEXIBLE COLD LOAD (TW) OVER SIMULATION
C           THESE VALUES ARE OVERRIDDEN IF IFGATHEAT=1
C
      IF (IFGATHEAT.NE.1) THEN
       AVINFHL = SUMINFHL / J
       AVINFCL = SUMINFCL / J
      ENDIF
C
C ***************************************************************************
C         READ TIME-DEPENDENT WIND, SOLAR SUPPLY DATA FROM GATOR-GCMOM
C ***************************************************************************
C CURLTWTB = CURRENT POWER GENERATION BY ONSHORE WIND TURBINES (TW) OVER
C            COUNTRY BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C            OF POWER FROM WIND BY EACH TURBINE.
C CUROTWTB = CURRENT POWER GENERATION BY OFFSHORE WIND TURBINES (TW) OVER
C            COUNTRY BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C            OF POWER FROM WIND BY EACH TURBINE.
C CURTWPVR = CURRENT ELEC GENERATED BY RES/COM/GOV ROOFTOP PV (TW)
C            (BEFORE T&D LOSSES) SUMMED OVER COUNTRY
C CURTWPVU = CURRENT ELEC GENERATED BY UTILITY PV (TW)
C            (BEFORE T&D LOSSES) SUMMED OVER COUNTRY
C CURTWCSP = CURRENT ELEC GENERATED BY SOLAR CSP (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CURTWSTH = CURRENT HEAT GENERATED BY SOLAR COLLECTORS (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CURTWHOT = CURRENT HEAT DEMAND (TW) FOR BUILDINGS IN COUNTRY
C CURTWCLD = CURRENT COLD DEMAND (TW) FOR BUILDINGS IN COUNTRY
C CUMLTWTB = CUMULATIVE POWER GEN BY ONSHORE WIND TURBINES (TW) OVER COUNTRY
C CUMOTWTB = CUMULATIVE POWER GEN BY OFFHORE WIND TURBINES (TW) OVER COUNTRY
C CUMTWRAV = CUM AVG ELEC GENERATED BY ROOFTOP PV (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWUAV = CUM AVG ELEC GENERATED BY UTILITY PV (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWCAV = CUM AVG ELEC GENERATED BY CSP (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWSAV = CUM AVG HEAT ENERATED BY SOLAR COLLECTORS (TW) (BEFORE T&D LOSSES)
C            SUMMED OVER COUNTRY
C CUMTWHOT = CURRENT HEAT DEMAND (TJ=TWxS) FOR BUILDINGS IN COUNTRY
C CUMTWCLD = CURRENT COLD DEMAND (TJ=TWxS) FOR BUILDINGS IN COUNTRY
C
C ***********************************************************************
C        SET TIME INCREMENT FOR GATOR-GCMOM WIND, SOLAR SUPPLY
C ***********************************************************************
C
C IWWS    = NUMBER OF TIME STEPS OF THE LOADMATCH SIMULATION
C TIMWWS  = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C PERHRS  = TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C IFONE   = 1: THEN THIS IS FIRST TIME>0 READ IN
C TIMLOAD = GMT HOUR OF SIMULATION (0.5 = 0-1 GMT JANUARY 1) CORRESPONDING TO
C           TIME OF LOAD DATA. VARIES FROM 0.5..NHRSIM-0.5
C
C SUMONWIND = CURRENT TW ONSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             AS DETERMINED FROM GATOR-GCMOM SIMULATIONS AT TIME J=1..IWWS
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C             WHEN IFCONUS=1, IT IS THE CONUS-AGGREGATE VALUE.
C SUMOFWIND = CURRENT TW OFFSHORE WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             BEFORE T&D LOSSES BUT ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C SUMROOFPV = CURRENT TW ROOF PV WIND, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES)
C SUMUTILPV = CURRENT TW UTILITY PV, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES) FROM GATOR-GCMOM
C SUMCSP    = CURRENT TW CSP, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES) FROM GATOR-GCMOM
C SUMSTHERM = CURRENT TW SOLAR THERMAL, SUMMED OVER ALL COUNTRIES IN GRID REGION
C             (BEFORE T&D LOSSES) FROM GATOR-GCMOM
C CURONSH   = CURRENT ONSHORE WIND POWER GENERATION (TW) AGGREGATED OVER
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C             DOMAIN AFTER T&D LOSSES AND ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C CUROFFSH  = CURRENT OFFSHORE WIND POWER GENERATION (TW) AGGREGATED OVER
C             DOMAIN AFTER T&D LOSSES AND ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C CUROOFPV  = CURRENT SOLAR POWER (TW) EXTRACTED FROM ROOF PV AFTER T&D LOSSES
C CURUTPV   = CURRENT SOLAR POWER (TW) EXTRACTED FROM UTILITY PV AFTER T&D LOSSES
C CURCSP    = CURRENT SOLAR POWER (TW) EXTRACTED FROM CSP AFTER T&D LOSSES
C             AFTER CSP BEYOND CUR CSP DISCHARGE RATE (EXTRACSP) PUT IN STORAGE
C CURSOLHT  = CURRENT SOLAR EXTRACTED FROM ROOF AND UTILITY HEAT
C             COLLECTORS (E.G., WATER OR GLYCOL SOLUTIONS)
C             OVER U.S. (TW) AFTER DISTRIBUTION LOSSES AND LOSSES FROM SOLAR
C             COLLECTOR ARE ACCOUNTED FOR (THUS, THIS IS ENERGY IN HOT FLUID)
C
C             THE SOLAR HEAT BEYOND EXISTING SOLAR HEAT
C             IS CONVERTED HERE TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF SOLAR THERMAL PROVIDES X
C             UNITS OF HEAT, IT PROVIDES THE EQUIVALENT OF X/CPERFORM UNITS OF
C             ELECTRICITY TO RUN HEAT PUMPS TO GENERATE THAT SAME HEAT
C
C             EXISTING SOLAR HEAT IS KEPT AS HEAT SINCE HEATING FOR 'WWS
C             HEAT' IN RAW IEA DATA IS KEPT AS HEAT (NOT CONVERTED TO
C             HEAT PUMPS). SAME AS ASSUMING HERE HEAT IS ELECTRIC BUT WITH
C             COP=1
C CPERFORM  = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C           = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
C           = 1 FOR ELECTRIC RESISTANCE HEATING
C           = 3.2-4.5 FOR AIR SOURCE HEAT PUMPS
C           = 4.2-5.2 FOR GROUND SOURCE HEAT PUMPS
C CPERF1    = CPERFORM = COEF OF PERFORMANCE OF HEAT PUMPS WHEN NEW SOLAR+GEOTHERMAL
C             HEAT ASSUMED. NEW SOLAR+GEOTHERMAL HEAT ARE ASSUMED TO BE
C             CONVERTED TO ELECTRICITY POWERING HEAT PUMPS
C           = 1 WHEN ONLY EXISTING SOLAR+GEOTHERMAL HEAT ASSUMED SINCE EXISTING
C             SOLAR+GEOTHERMAL HEAT IS TREATED AS HEAT IN IEA DATABASE
C             SO NO NEED TO CONVERT TO EQUIVALENT ELECTRICITY
C FACSHT    = FACTOR TO MULTIPLY DELIVERED SOLAR PV+CSP BY TO ESIMATE SOLAR
C             HEAT FROM ROOF OR UTILITY HEAT COLLECTORS (E.G., WATER, GLYCOL)
C TDEFFMN   = 1-TDLOSMN=TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C EFFSOLCOL = EFFICIENCY OF SOLAR COLLECTOR FOR HOT WATER/GLYCOL
C           = ENERGY IN HOT FLUID DIVIDED BY INCIDENT SOLAR RADIATION
C           = 0.34 FROM TABLE 2 OF SIBBITT ET AL ENERGY PROCEDIA 30, 856, 2012
C RATIOCSP  = RATIO OF TW OF CSP COLLECED IN MIRRORS FOR DIRECT ELECTRICITY
C             USE OR STORAGE TO THAT USED TO DERIVE OUTPUT IN KWWS (WHICH IS
C             BASED ONLY ON DISCHARGE RATE)
C           = CSPCHARG / TWCSPGAT
C EXTRACSP  = CSP SOLAR (TW) THAT CAN'T BE USED IMMEDIATELY BUT THAT CAN
C             GO STRAIGHT TO CSP STORAGE
C CSPCOLL   = TW CSP IN KWWS ADJUSTED FOR NUMBER OF CSP MIRRORS HERE
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C           = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C RATONSHW  = RATIO OF INSTALLED TW ONSHORE WIND ACTUALLY NEEDED TO
C             THAT USED IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C RATOFFSHW = RATIO OF INSTALLED TW OFFSHORE WIND ACTUALLY NEEDED TO
C             THAT USED IN GATOR-GCMOM TO DERIVE OUTPUT IN KWWS
C FACROOFPV = WEIGHTED AVG VALUE OF FACRESPV AND FACCOMPV
C             USED TO MULTIPLY DELIVERED TOTAL ROOFTOP PV FROM
C             GATOR-GCMOM BY
C
      DO J        = 1, IWWS
       IYY        = IYRWWS(J)
       IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
C
        CURONSH( J) = SUMONWIND(J)*TDEFFMN(IONWIND) *FACONWIN *RATONSHW
        CUROFFSH(J) = SUMOFWIND(J)*TDEFFMN(IOFFWIND)*FACOFFWIN*RATOFFSHW
        CUROOFPV(J) = SUMROOFPV(J)*TDEFFMN(IRESPV)  *FACROOFPV*RATROOFPV
        CURUTPV( J) = SUMUTILPV(J)*TDEFFMN(IUTILPV) *FACUTILPV*RATUTILPV
        CURSOLHT(J) = SUMSTHERM(J)*TDEFFMN(ISOLTHM) *FACSHT   *RATSHEAT
     1              / CPERF1
        CSPCOLL     = SUMCSP(   J)*TDEFFMN(ICSPSTOR)          *RATIOCSP
C
        IF (CSPCOLL.GT.CSPDISCH) THEN
         EXTRACSP(J) = CSPCOLL - CSPDISCH
```

```
         CURCSP(  J) = CSPDISCH
        ELSE
         CURCSP(  J) = CSPCOLL
        ENDIF
C
C CSHTMAX = MAX VALUE OF CURSOLHT (TW) DURING SIMULATION
C
        CSHTMAX      = MAX(CURSOLHT(J),CSHTMAX)
C
C AVWINPOW = INITIALLY TWH-WIND OFFSHORE WIND OVER ENTIRE KWWS DATASET
C
        AVWINPOW(IYY) = AVWINPOW(IYY) + CUROFFSH(J) * PERHRS(J)
C
       ENDIF
C      ENDIF TIMWWS>0
      ENDDO
C     ENDDO J = 1, IWWS
C
      IF (TWINUTES.GT.0.) THEN
       CSHTW = CSHTMAX / TWINUTES
      ELSE
       CSHTW = 0.
      ENDIF
C
      WRITE(IOUT,151) CSHTMAX,TWINUTES,CSHTW,FACSHT
C
 151  FORMAT(/'CSHTMAX, TWINUTES, CSHTMAX/TWINUTES    = ',3(0PF12.4),/
     1       'FACSHT= ',0PF12.4,' CAN BE ADJUSTED TO CSHTMAX/TWINUTES',/
     1       'TO ENSURE TWINUTES (MAX CHARGE RATE UTES) = CSHTMAX',/)
C
C AVWINPOW = ANNUAL AVG OFFSHORE WIND POWER (TW) EACH YEAR
C            MAKE SURE NOT = 0 SINCE WAVE POWER CALCULATED FROM THIS.
C HRSINYR  = HOURS OF DATA DURING EACHYEAR IYY
C
      DO I         = 1, NYEARS
       AVWINPOW(I) = SMAL30 + AVWINPOW(I) / HRSINYR(I)
      ENDDO
C
C ***********************************************************************
C PRINT CAPACITY FACTOR BY COUNTRY FOR EACH ENERGY DEVICE AS DETERMINED
C FROM GATOR-GCMOM SIMULATIONS WITH INSTALLED CAPACITIES TGWINSTGAT
C ***********************************************************************
C TGWINSTGAT = NEW+EXIST INSTALLED GW 1..MXCAP DEVICE BY COUNTRY GATOR-GCMOM SIMS
C              FOR CSP, NEED TO ADD TMWCSPAGAT HERE.
C NAMECOUN   = NAME OF EACH 1..NCOUNTRY COUNTRY
C CF1..6     = CAPACITY FACTOR OF ENERGY DEVICE AVERAGED OVER SIMULATION
C              AND FOR EACH COUNTRY.
C ENCOUNTRY  = CUMULATIVE ENERGY PRODUCTION (TWH) OVER SIMULATION FROM
C              ENERGY DEVICE OVER DOMAIN BEFORE T&D LOSSES BUT ACCOUNTING
C              FOR EXTRACTION OF POWER FROM WIND BY TURBINES
C GWPTW     = 1000.    GIGAWATTS (GW) PER TERAWATT (TW)
C SUMEN     = SUM OF CUM EN PROD ENCOUNTRY (TWH) EACH DEVICE OVER ALL COUNTRIES
C SUMNP     = SUM NAMEPLATE CAPAC TGWINSTGAT (GW) EACH DEVICE OVER ALL COUNTRIES
C ISERBMON  = IDENTIFIES 1..NCOUNTRY COUNTRY 'SERBIA AND MON'
C IMONT     = IDENTIFIES 1..NCOUNTRY COUNTRY 'MONTENEGRO    '
C
      IF (IFREWRITE.EQ.2.AND.IFCONUS.EQ.0) THEN
       WRITE(KOUT,154) ADDHOURS / 24.
C
C SUM VALUES FOR SERBIA AND MONTENEGRO INTO SERBIA + MONTENEGRO
C
       IF (IMONT.GT.0.AND.ISERBMON.GT.0) THEN
        DO J      = 1, MXCAP
         ENCOUNTRY( ISERBMON,J) = ENCOUNTRY(ISERBMON,J)
     1                          + ENCOUNTRY(IMONT,   J)
         TGWINSTGAT(ISERBMON,J) = TGWINSTGAT(ISERBMON,J)
     1                          + TGWINSTGAT(IMONT,   J)
         ENCOUNTRY( IMONT,   J) = 0.
         TGWINSTGAT(IMONT,   J) = 0.
        ENDDO
       ENDIF
C
C PRINT OUT CAPACITY FACTORS AND NAMEPLATE CAPCITIES GW) FROM GATOR-GCMOM
C
       DO IC      = 1, NCOUNTRY
```

```
        DO J      = 1, MXCAP
         SUMEN(J) = SUMEN(J) + ENCOUNTRY( IC,J)
         SUMNP(J) = SUMNP(J) + TGWINSTGAT(IC,J)
        ENDDO
C
        TGWINROOFPV = TGWINSTGAT(IC,IRESPV) + TGWINSTGAT(IC,ICOMGVPV)
        CF1 = ENCOUNTRY(IC,IONWIND)  * GWPTW /
     1         (ADDHOURS * (TGWINSTGAT(IC,IONWIND)  + SMAL30))
        CF2 = ENCOUNTRY(IC,IOFFWIND) * GWPTW /
     1         (ADDHOURS * (TGWINSTGAT(IC,IOFFWIND) + SMAL30))
        CF3 = ENCOUNTRY(IC,IRESPV)   * GWPTW /
     1         (ADDHOURS * (TGWINROOFPV             + SMAL30))
        CF4 = ENCOUNTRY(IC,IUTILPV)  * GWPTW /
     1         (ADDHOURS * (TGWINSTGAT(IC,IUTILPV)  + SMAL30))
        CF5 = ENCOUNTRY(IC,ICSPSTOR) * GWPTW /
     1         (ADDHOURS * (TGWINSTGAT(IC,ICSPSTOR) + SMAL30))
        CF6 = ENCOUNTRY(IC,ISOLTHM)  * GWPTW /
     1         (ADDHOURS * (TGWINSTGAT(IC,ISOLTHM)  + SMAL30))
        WRITE(KOUT,155) NAMECOUN(IC),
     1    TGWINSTGAT(IC,IONWIND), CF1,TGWINSTGAT(IC,IOFFWIND),CF2,
     1    TGWINROOFPV,            CF3,TGWINSTGAT(IC,IUTILPV), CF4,
     1    TGWINSTGAT(IC,ICSPSTOR),CF5,TGWINSTGAT(IC,ISOLTHM), CF6
       ENDDO
C
       TGWINROOFPV = SUMNP(IRESPV) + SUMNP(ICOMGVPV)
       CF1 = SUMEN(IONWIND)  * GWPTW / (ADDHOURS * SUMNP(IONWIND))
       CF2 = SUMEN(IOFFWIND) * GWPTW / (ADDHOURS * SUMNP(IOFFWIND))
       CF3 = SUMEN(IRESPV)   * GWPTW / (ADDHOURS * TGWINROOFPV)
       CF4 = SUMEN(IUTILPV)  * GWPTW / (ADDHOURS * SUMNP(IUTILPV))
       CF5 = SUMEN(ICSPSTOR) * GWPTW / (ADDHOURS * SUMNP(ICSPSTOR))
       CF6 = SUMEN(ISOLTHM)  * GWPTW / (ADDHOURS * SUMNP(ISOLTHM))
C
       WRITE(KOUT,155) 'ALL-COUNTRIES ',
     1   SUMNP(IONWIND),  CF1, SUMNP(IOFFWIND), CF2,
     1   TGWINROOFPV,     CF3, SUMNP(IUTILPV),  CF4,
     1   SUMNP(ICSPSTOR), CF5, SUMNP(ISOLTHM),  CF6
C
 154   FORMAT('DAYS OVER WHICH CAPACITY FACTOR CF CALCULATED ',0PF9.3,/
     1        'COUNTRY        ',
     1        'GW-ONWIND   CF  GW-OFFWND   CF  GW-ROOFPV   CF  ',
     1        'GW-UTILPV   CF  GW-CSPSTO   CF  GW-SOLTHM   CF')
 155   FORMAT(A14,1X,6(1X,0PF9.3,1X,0PF5.3))
C
       STOP
      ENDIF
C     ENDIF IFREWRITE=2 AND IFCONUS=0
C
C **********************************************************************
C         DISTRIBUTE WAVE POWER PROPORTIONALLY TO WIND POWER
C **********************************************************************
C CURWAVP   = 2050 CONUS WAVE POWER (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C             DISTRIBUTED PROPORTIONALLY TO WIND SUPPLY PROFILE
C             CURWAVP(J) * PERHRS(J) / ADDHOURS = CURWAV
C CURWAV    = 2050 CONUS WAVE DELIVERED POWER AFTER T&D LOSSES(TW)
C AVWINPOW  = ANNUAL AVG OFFSHORE WIND POWER (TW) EACH YEAR
C CUROFFSH  = CURRENT OFFSHORE WIND POWER GENERATION (TW) AGGREGATED OVER
C             DOMAIN AFTER T&D LOSSES AND ACCOUNTING FOR EXTRACTION
C             OF POWER FROM WIND BY EACH TURBINE.
C CURCLOAD  = CURRENT BUILDING COLD LOAD (TW) FOR REGION AFTER SCALING
C             ANNUAL AVG COLD LOAD BY CURRENT TO AVG LOAD IN GATOR-GCMOM
C             THESE ARE LOADS SUBJECT TO DISTRICT HEATING COLD STORAGE
C CURHLOAD  = CURRENT BUILDING HEAT LOAD (TW) SUBJECT TO STORAGE FOR REGION
C             AFTER SCALING ANNUAL AVG HEAT LOAD BY CURRENT TO AVG LOAD
C TSTORAWH  = ANNUAL LOAD (TW) FOR AIR AND WATER HEATING SUBJECT TO STORAGE
C             INCLUDES DISTRICT HEATING STORAGE+DOMESTIC WATER TANK STORAGE
C AVHEATLD  = ANNUAL AVG BUILDING HEAT LOAD (TW) OVER ENTIRE KWWS DATASET
C AVCOLDLD  = ANNUAL AVG BUILDING COLD LOAD (TW) OVER ENTIRE KWWS DATASET
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C ELECCOLD  = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C ELECHOT   = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
C EVINFLEX  = ANNUAL AVG ELEC LOAD FOR CHARGING EVS (TW) THAT IS INFLEXIBLE
C             (ALL LOAD FOR CHARGING H2 FUEL CELL VEHICLES IS FLEXIBLE)
C CINFXCLD  = CURRENT ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C CINFXHLD  = CURRENT ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
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C CURFLOAD  = TLOADDRM, BUT WITH COLDFLEX AND HOTFLEX CONVERTED FROM
C             ANNUAL AVERAGE NUMBERS TO TIME-DEPENDENT NUMBERS WITH SAME
C             ANNUAL AVERAGE TOTA CONVERTED FROM
C CURCFLEX  = CURRECT LOAD (TW) SUBJECT TO DRM THAT IS BUILDING COLD LOAD
C CURHFLEX  = CURRECT LOAD (TW) SUBJECT TO DRM THAT IS BUILDING HEAT LOAD
C CURVFLEX  = CURRECT LOAD (TW) SUBJECT TO DRM THAT IS ELEC VEH (NOT H2 FCV) LOAD
C COLDFLEX  = PORTION OF COLD LOAD (TW) NOT MET BY STORAGE THAT CAN
C             BE MET BY DEMAND RESPONSE.
C HOTFLEX   = PORTION OF WARM LOAD (TW) NOT MET BY STORAGE THAT CAN
C             BE MET BY DEMAND RESPONSE.
C TFLEXEVS  = FLEXIBLE TRANSPORTATION LOAD FOR ELECTRIC VEHICLES (TW)
C             THE REST OF FLEXIBLE TRANSPORT LOAD IS FOR H2FC VEHICLES
C TLOADDRM  = TOTAL LOAD (TW) SUBJECT TO DEMAND-RESPONSE MANAG LESS H2
C FSTPCOOL  = FRAC OF ANNUAL AVG COLD LOAD OCCURRING IN GIVEN TIME STEP
C FSTPWARM  = FRAC OF ANNUAL AVG WARM LOAD OCCURRING IN GIVEN TIME STEP
C FSTPVEH   = FRAC OF AN AVG FLEX EV (NOT H2FCV) LOAD OCCURRING IN GIVEN TIME STEP
C
      SUMCWAV      = 0.
      SUMCHL       = 0.
      SUMCCL       = 0.
      SUMFLL       = 0.
      SUMINFHL     = 0.
      SUMINFCL     = 0.
      SUMINFVL     = 0.
      DO J         = 1, IWWS
       IYY         = IYRWWS(J)
       IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
        CURWAVP( J) = CURWAV    * CUROFFSH(J) / AVWINPOW(IYY)
        SUMCWAV     = SUMCWAV   + CURWAVP( J) * PERHRS(J)
C
        IF (IFGATHEAT.EQ.1) THEN
         CURHLOAD(J) = TSTORAWH  * FSTPWARM(J)
         CURCLOAD(J) = TSTORCOOL * FSTPCOOL(J)
C
         CURHFLEX(J) = HOTFLEX   * FSTPWARM(J)
         CURCFLEX(J) = COLDFLEX  * FSTPCOOL(J)
         CURVFLEX(J) = TFLEXEVS  * FSTPVEH( J)
C
         CURFLOAD(J) = TLOADDRM  + CURCFLEX(J) - COLDFLEX
     1                           + CURHFLEX(J) - HOTFLEX
     1                           + CURVFLEX(J) - TFLEXEVS
C
         CINFXHLD(J) = ELECHOT   * FSTPWARM(J)
         CINFXCLD(J) = ELECCOLD  * FSTPCOOL(J)
         CINFXVEH(J) = EVINFLEX  * FSTPVEH( J)
C
         SUMCHL      = SUMCHL    + CURHLOAD(J) * PERHRS(J)
         SUMCCL      = SUMCCL    + CURCLOAD(J) * PERHRS(J)
         SUMFLL      = SUMFLL    + CURFLOAD(J) * PERHRS(J)
         SUMINFHL    = SUMINFHL  + CINFXHLD(J) * PERHRS(J)
         SUMINFCL    = SUMINFCL  + CINFXCLD(J) * PERHRS(J)
         SUMINFVL    = SUMINFVL  + CINFXVEH(J) * PERHRS(J)
        ENDIF
C
C CURGEOP   = 2050 REGIONAL GEOTHERM (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C CURGEOEL  = 2050 REGIONAL GEOTHERMAL DELIV ELEC POWER AFTER T&D LOSSES (TW)
C CURTIDP   = 2050 REGIONAL TIDAL (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C CURTID    = 2050 REGIONAL TIDAL DELIVERED POWER AFTER T&D LOSSES (TW)
C CURGEOH   = 2050 REGIONAL GEOTHERM HEAT EACH 1..IWWS TIME STEP AFTER T&D LOSS (TW)
C
C             THE HEAT FOR NEW GEOTHERMAL HEAT BEYOND CURRENT GEOTHERMAL HEAT
C             IS CONVERTED TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF GEOTHERMAL PROVIDES X
C             UNITS OF HEAT, IT PROVIDES THE EQUIVALENT OF X/CPERFORM UNITS OF
C             ELECTRICITY TO RUN HEAT PUMPS TO GENERATE THAT HEAT
C
C             EXISTING GEOTHERMAL HEAT IS KEPT AS HEAT SINCE HEATING FOR 'WWS
C             HEAT' IN RAW IEA DATA IS KEPT AS HEAT (NOT CONVERTED TO
C             HEAT PUMPS). SAME AS ASSUMING HERE HEAT IS ELECTRIC BUT WITH
C             COP=1
C CURGEOHT  = 2050 CONUS GEOTHERMAL HEAT DELIVERED AFTER T&D LOSSES (TW)
C CPERFORM  = COEFFICIENT OF PERFORMANCE OF HEAT PUMPS
C           = RATIO OF JOULES OF HEAT MOVED OR PRODUCED PER JOULE OF ELECTRICITY
```

```
C CPERF1    = CPERFORM = COEF OF PERFORMANCE OF HEAT PUMPS WHEN NEW SOLAR+GEOTHERMAL
C             HEAT ASSUMED. NEW SOLAR+GEOTHERMAL HEAT ARE ASSUMED TO BE
C             CONVERTED TO ELECTRICITY POWERING HEAT PUMPS
C           = 1 WHEN ONLY EXISTING SOLAR+GEOTHERMAL HEAT ASSUMED SINCE EXISTING
C             SOLAR+GEOTHERMAL HEAT IS TREATED AS HEAT IN IEA DATABASE
C             SO NO NEED TO CONVERT TO EQUIVALENT ELECTRICITY
C
        CURGEOP(J) = CURGEOEL
        CURTIDP(J) = CURTID
        CURGEOH(J) = CURGEOHT / CPERF1
       ENDIF
C      ENDIF TIMWWS > 0
      ENDDO
C     ENDDO J = 1, IWWS
C
      WRITE(IOUT,152) IGRIDUSE, IGEUROPE
 152  FORMAT('IGRIDUSE IGEUROPE = ',I3,I3)
C
C ADDHOURS  = HOURS OF DATA OVER ENTIRE KWWS DATASET
C
      WRITE(IOUT,153) SUMCWAV/ADDHOURS, CURWAV,    ADDHOURS
C
C TAVCOOL = AVERAGE COOLING LOAD SUBJECT TO STORAGE (TW) OVER SIMULATION
C TAVWARM = AVERAGE HEATING LOAD SUBJECT TO STORAGE (TW) OVER SIMULATION
C TAVFLEX = AVERAGE HOT+COLD FLEX LOAD  SUBJECT TO DEM-RESPONSE (TW) OVER SIM
C AVINFHL = AVERAGE INFLEXIBLE HEAT LOAD (TW) OVER SIMULATION
C AVINFCL = AVERAGE INFLEXIBLE COLD LOAD (TW) OVER SIMULATION
C
      IF (IFGATHEAT.EQ.1) THEN
       TAVWARM  = SUMCHL   / ADDHOURS
       TAVCOOL  = SUMCCL   / ADDHOURS
       TAVFLEX  = SUMFLL   / ADDHOURS
       AVINFHL  = SUMINFHL / ADDHOURS
       AVINFCL  = SUMINFCL / ADDHOURS
       AVINFVL  = SUMINFVL / ADDHOURS
C
       WRITE(IOUT,156) TAVWARM, TSTORAWH,  ADDHOURS
       WRITE(IOUT,157) TAVCOOL, TSTORCOOL, ADDHOURS
       WRITE(IOUT,281) TAVFLEX, TLOADDRM,  ADDHOURS
       WRITE(IOUT,279) AVINFHL, ELECHOT,   ADDHOURS
       WRITE(IOUT,280) AVINFCL, ELECCOLD,  ADDHOURS
       WRITE(IOUT,294) AVINFVL, EVINFLEX,  ADDHOURS
      ENDIF
C
 153  FORMAT('ANN-AVG WAVEPOW  CURWAV   (TW) HRSOFDATA',3(0PF14.6))
 156  FORMAT('ANN-AVG HEATSTOR TSTORAWH (TW) HRSOFDATA',3(0PF14.6))
 157  FORMAT('ANN-AVG COLDSTOR TSTORCOOL(TW) HRSOFDATA',3(0PF14.6))
 281  FORMAT('ANN-AVG HOTCDDRM TLOADDRM (TW) HRSOFDATA',3(0PF14.6))
 279  FORMAT('ANN-AVG INFXHEAT ELECHOT  (TW) HRSOFDATA',3(0PF14.6))
 280  FORMAT('ANN-AVG INFXCOLD ELECCOLD (TW) HRSOFDATA',3(0PF14.6))
 294  FORMAT('ANN-AVG INFXVEH  EVINFLEX (TW) HRSOFDATA',3(0PF14.6))
C
C **********************************************************************
C      SUM STATISTICS FOR HISTOGRAM OF HOURLY LOAD AND SUPPLY
C **********************************************************************
C TIMWWS  = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C TIMLOAD = GMT HOUR OF SIMULATION (0.5 = 0-1 GMT JANUARY 1) CORRESPONDING TO
C           TIME OF LOAD DATA. VARIES FROM 0.5..NHRSIM-0.5
C BLOAD   = 2050 HOURLY NON-COLD, NOT HOT INFLEX LOAD (TW) ACROSS ALL SECTORS
C           FOR GRID REGION. EXTRAPOLATED FROM CURRENT TO 2050
C CLOAD   = VALUES OF BLOAD (TW) + INFLEX HOT+COLD LOAD FOR EACH TIMWWS TIME INCREMENT
C         = 2050 HOURLY INFLEXIBLE LOAD (TW)
C PERHRS  = TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C IYRWWS  = YEAR 1..MXYEAR CORRESPONDING TO EACH J=1..IWWS TIMESTEP
C
C COPY LOAD DATA (TW) TO EACH TIME THAT WWS DATA AVAILABLE. POWER IS
C INSTANTANEOUS SO NO NEED TO CHANGE UNITS.
C
      ILAST       = 1
      DO 220 J    = 1, IWWS
       IYY        = IYRWWS(J)
C
C **********************************************************************
C     INITIALIZE LOAD WITH INFLEXIBLE LOAD WHEN HIRES LOAD DATA
C **********************************************************************
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C MXTSHRALL = MAX NUMBER 30-SEC TIME STEPS IN ALL YEARS OF SIMULATION
C NTSSIM    = TOTAL NUMBER OF HIGH-RES (30-S) TIMES STEPS OF SIMULATION
C TLOADHR   = GMT HOUR OF SIM (-0.000833 = -15 TO +15 SEC JANUARY 1) CORRESPONDING TO
C             TIME OF HIGH-RESOLUTION LOAD DATA. VARIES FROM -0.000833...NHRSIM-0.0091667
C             0.0091667=1.1*FHOURHR
C DLOAD     = 2050 30-SECOND INFLEXIBLE, NON-COLD, NON-HOT LOAD DATA (TW) ACROSS
C             ALL ENERGY SECTORS FOR GRID REGION FROM LOAD DATA
C
       IF (IFHRLOAD.EQ.1) THEN
        DO I       = ILAST, MXTSHRALL-1
         IF (TIMWWS(J).GE.TLOADHR(I).AND.TIMWWS(J).LT.TLOADHR(I+1).AND.
     1       TIMWWS(J).LT.TLOADHR(NTSSIM)) THEN
          CLOAD(J) = DLOAD(I)
          ILAST    = I
          GOTO 218
         ENDIF
        ENDDO
 218    CONTINUE
       ENDIF
C
C **********************************************************************
C     INITIALIZE LOAD WITH INFLEXIBLE LOAD WHEN HOURLY LOAD DATA
C      AND COMPLETE LOAD IN ALL CASES WITH HOURLY HEAT/COLD LOADS
C **********************************************************************
C
       DO 216 I   = 1, MXLOADYR - 1
        IF (TIMWWS(J).GE.TIMLOAD(I).AND.TIMWWS(J).LT.TIMLOAD(I+1).AND.
     1      TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
C
C ELECCOLD  = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C ELECHOT   = ANNUAL AVG ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
C CINFXCLD  = CURRENT ELEC LOAD (TW) TO SATISFY INFLEX COLD LOAD W/HEAT PUMPS
C CINFXHLD  = CURRENT ELEC LOAD (TW) TO SATISFY INFLEX HOT LOAD W/HEAT PUMPS
C
         IF (IFHRLOAD.EQ.0) THEN
          CLOAD(J) = BLOAD(I)
         ENDIF
C
         IF (IFGATHEAT.EQ.1) THEN
          CLOAD(J) = CLOAD(J) + CINFXHLD(J) + CINFXCLD(J)
         ELSE
          CLOAD(J) = CLOAD(J) + HOTHOUR(I) + COLDHOUR(I)
         ENDIF
C
C AMAXLOAD  = MAXIMUM LOAD (TW) ANY TIME BETWEEN 1..NYEARS
C AMINLOAD  = MINIMUM LOAD (TW) ANY TIME BETWEEN 1..NYEARS
C TIMAXLOAD = HOUR OF SIMULATION OF MAXIMUM LOAD AMAXLOAD
C TIMINLOAD = HOUR OF SIMULATION OF MINIMUM LOAD AMINLOAD
C RAMPMAX   = MAX LOAD RAMP RATE (TW/HR) (UP ONLY) BETWEEN TWO CONSEC TIMES
C TIMAXRAMP = HOUR OF SIMULATION OF END OF GREATEST RAMP RAMPMAX
C RAMPRATE  = CURRENT LOAD RAMP RATE (TW/HR) (UP OR DOWN) BETWEEN TWO CONSEC TIMES
C
         IF (CLOAD(J).GT.AMAXLOAD(IYY)) THEN
          AMAXLOAD( IYY) = CLOAD( J)
          TIMAXLOAD(IYY) = TIMWWS(J)
         ENDIF
C
         IF (CLOAD(J).LT.AMINLOAD(IYY)) THEN
          AMINLOAD( IYY) = CLOAD( J)
          TIMINLOAD(IYY) = TIMWWS(J)
         ENDIF
C
         IF (J.GT.1) THEN
          RAMPRATE   = (CLOAD( J) - CLOAD( J-1)) /
     1                 (TIMWWS(J) - TIMWWS(J-1))
          IF (RAMPRATE.GT.RAMPMAX(IYY)) THEN
           RAMPMAX(  IYY) = RAMPRATE
           TIMAXRAMP(IYY) = TIMWWS(J)
          ENDIF
         ENDIF
C
C DEMAND   = 2050 CURRENT INFLEXIBLE ENERGY DEMAND OVER TIME INTERVAL PERHRS (TWH)
C CLOAD    = VALUES OF BLOAD (TW) FOR EACH TIMWWS TIME INCREMENT
C          = 2050 HOURLY INFLEXIBLE LOAD (TW)
C SUPPLY   = CURRENT WIND AND SOLAR ENERGY SUPPLY OVER TIME INTERVAL PERHRS (TWH)
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C             AFTER T&D LOSSES ACCOUNTED FOR
C SUPPHT    = CURRENT HEAT (TWH) FROM SOLAR HOT WATER OR GLYCOL SOLUTION COLLECTORS
C             OR GEOTHERMAL HEAT OVER TIME INTERVAL PERHRS - AFTER DISTRIBUTION LOSSES
C             ACCOUNTED FOR AND AFTER COLLECTOR EFFICIENCY ACCOUNTED FOR.
C
C             FOR HEAT BEYOND WHAT WAS EXISTING IN BASE YEAR,
C             THE HEAT IS CONVERTED TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF GEOTHERMAL PROVIDES X
C             UNITS OF HEAT, THE ELECTRICITY REQUIRED IS X / CPERFORM UNITS
C
C             FOR HEAT IN THE BASE YEAR, THE HEAT IS KEPT AS HEAT
C             (CPERFORM=1) SINCE IEA DATABASE INCLUDES WWS HEAT FOR BASE
C             YEAR
C
C CURCSP    = CURRENT SOLAR POWER (TW) EXTRACTED FROM CSP AFTER T&D LOSSES
C             AFTER CSP BEYOND CUR CSP DISCHARGE RATE (EXTRACSP) PUT IN STORAGE
C CURSOLHT = CURRENT SOLAR EXTRACTED FROM ROOF AND UTILITY HEAT
C             COLLECTORS (E.G., WATER OR GLYCOL SOLUTIONS)
C             OVER U.S. (TW) AFTER DISTRIBUTION LOSSES AND LOSSES FROM SOLAR
C             COLLECTOR ARE ACCOUNTED FOR (THUS, THIS IS ENERGY IN HOT FLUID)
C             THE HEAT IS CONVERTED TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF SOLAR THERMAL PROVIDES X
C             UNITS OF HEAT, IT PROVIDES X / CPERFORM UNITS OF
C             ELECTRICITY TO RUN HEAT PUMPS TO GENERATE THAT HEAT
C TWHONWIN = CUMULATIVE TWH ONSHORE WIND PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHOFFWIN= CUMULATIVE TWH OFFSHORE WIND PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHROOFPV= CUMULATIVE TWH ROOF PV PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHUTILPV= CUMULATIVE TWH UTILITY PV PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHCSP   = CUMULATIVE TWH UTILITY CSP PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHSTCSP = CUMULATIVE TWH OF CSP THAT GOES STRAIGHT TO STORAGE (AFTER T&D LOSS)
C TWHHYD   = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHPKHYD = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHBSHYD = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHWAV   = CUMULATIVE TWH WAVE PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHGEOEL = CUMULATIVE TWH GEOTHERMAL ELEC PROD DURING SIM (AFTER T&D LOSSES)
C TWHTID   = CUMULATIVE TWH TIDAL PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHTHEAT = CUMULATIVE TWH SOLAR THERMAL HEAT PROD DURING SIM (AFTER T&D LOSSES)
C TWHGEOHT = CUMULATIVE TWH GEOTHERMAL HEAT PROD DURING SIM (AFTER T&D LOSSES)
C HRSSIM   = NUMBER OF HOURS OF SIMULATION (HOURS)
C CURGEOP  = 2050 GEOTHERM ELEC (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C CURGEOH  = 2050 GEOTHERM HEAT (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C             THE HEAT WAS CONVERTED EARLIER TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF GEOTHERMAL PROVIDES X
C             UNITS OF HEAT, IT PROVIDES X / CPERFORM UNITS OF
C             ELECTRICITY TO RUN HEAT PUMPS TO GENERATE THAT HEAT
C CURTIDP  = 2050 CONUS TIDAL (TW) EACH 1..IWWS TIME STEP AFTER T&D LOSSES
C EXTRACSP = CSP SOLAR (TW) THAT CAN'T BE USED IMMEDIATELY BUT THAT CAN
C             GO STRAIGHT TO CSP STORAGE
C BASHAFT   = 2050 REGIONAL DELIVERED HYDRO FOR BASELOAD AFTER T&D LOSSES (TW)
C PKHAFT    = 2050 REGIONAL DELIVERED HYDRO FOR PEAKING AFTER T&D LOSSES (TW)
C
         DEMAND(J) = CLOAD(J) * PERHRS(J)
C
         SUPPLY(J) = (CURONSH( J) + CUROFFSH(J)
     1              +  CUROOFPV(J) + CURUTPV( J) + CURCSP(J)
     1              +  CURWAVP( J) + CURGEOP(J)
     1              +  CURTIDP( J) + BASHAFT) * PERHRS(J)
         SUPPHT(J) = (CURSOLHT(J) + CURGEOH(J)) * PERHRS(J)
         TWHONWIN  = TWHONWIN  + CURONSH( J) * PERHRS(J)
         TWHOFFWIN = TWHOFFWIN + CUROFFSH(J) * PERHRS(J)
         TWHROOFPV = TWHROOFPV + CUROOFPV(J) * PERHRS(J)
         TWHUTILPV = TWHUTILPV + CURUTPV( J) * PERHRS(J)
         TWHCSP    = TWHCSP    + CURCSP(  J) * PERHRS(J)
         TWHSTCSP  = TWHSTCSP  + EXTRACSP(J) * PERHRS(J)
         TWHWAV    = TWHWAV    + CURWAVP( J) * PERHRS(J)
         TWHGEOEL  = TWHGEOEL  + CURGEOP( J) * PERHRS(J)
         TWHTID    = TWHTID    + CURTIDP( J) * PERHRS(J)
         TWHTHEAT  = TWHTHEAT  + CURSOLHT(J) * PERHRS(J)
         TWHGEOHT  = TWHGEOHT  + CURGEOH( J) * PERHRS(J)
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         TWHHYD    = TWHHYD    + BASHAFT     * PERHRS(J)
         TWHBSHYD  = TWHBSHYD  + BASHAFT     * PERHRS(J)
         HRSSIM    = HRSSIM  +                 PERHRS(J)
C
C TIMWWS = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C GMTDAY = GMT DAYS   PAST JAN. 1 AT 0 GMT
C IGMTD  = 1..NDSIM GMT DAY OF SIM, ACCOUNTING FOR LEAP YEARS.
C          (1 = JAN 1 OF FIRST YEAR; 2 = JAN 2, ETC.)
C GMTHR  = 0..23 GMT HOUR OF DAY, FOR ANY DAY OF THE YEAR
C IGMTH  = 1..24 GMT HOUR OF DAY, FOR ANY DAY OF THE YEAR
C        = 1 IS FOR TIME BETWEEN 0 AND 1 GMT
C JGMTH  = 1...NHRSIM GMT HOUR OF SIMULATION. 1 IS FOR TIME BETWEEN
C          0 AND 1 GMT ON JAN 1 OF FIRST YEAR
C
         GMTDAY       = TIMWWS(J) / 24.
         IGMTD        = INT(GMTDAY) + 1
         GMTHR        = MOD(TIMWWS(J),24.)
         IGMTH        = INT(GMTHR) + 1
         JGMTH        = INT(TIMWWS(J)) + 1
C
         IF (IGMTD.GT.NDSIM.OR.JGMTH.GT.NHRSIM) THEN
          WRITE(IOUT,*)'POWERWORLD: IGMTD>NDSIM OR JGMTH>NHRSIM ',
     1                 IGMTD,NDSIM,JGMTH,NHRSIM,
     1                 TIMWWS(J),TIMLOAD(NHRSIM),J
          STOP
         ENDIF
C
C NTIMSTEPS = NUMBER OF J=1..IWWS TIME STEPS DURING GMT HOUR
C
         NTIMSTEPS(JGMTH) = NTIMSTEPS(JGMTH) + 1
C
C ENONWIN = CUR ENERGY (TWH) GEN BY ONSHORE WIND DUR PERIOD PERHRS AFTER T&D LOSS
C ENOFFWIN= CUR ENERGY (TWH) GEN BY OFFSHORE WIND DUR PERIOD PERHRS AFTER T&D LOSS
C ENROOFPV= CUR ENERGY (TWH) GEN BY ROOF PV DURING PERIOD PERHRS AFTER T&D LOSS
C ENUTILV = CUR ENERGY (TWH) GEN BY UTIL PV DURING PERIOD PERHRS AFTER T&D LOSS
C ENCSP   = CUR ENERGY (TWH) GEN BY CSP ENERGY DURING PERIOD PERHRS AFTER T&D LOSS
C ENWAV   = CUR ENERGY (TWH) GEN BY WAVE DURING PERIOD PERHRS AFTER T&D LOSS
C ENGEO   = CUR ENERGY (TWH) GEN BY GEOTHERMAL DUR PERIOD PERHRS AFTER T&D LOSS
C ENTID   = CUR ENERGY (TWH) GEN BY TIDAL DURING PERIOD PERHRS AFTER T&D LOSS
C ENHYD   = CUR ENERGY (TWH) GEN BY HYDROPOWER DUR PERIOD PERHRS AFTER T&D LOSS
C ENSHT   = CUR ENERGY (TWH) GEN BY SOLAR-THERMAL DUR PERIOD PERHRS AFTER T&D LOSS
C ENGHT   = CUR ENERGY (TWH) GEN BY GEOTH HEAT DUR PERIOD PERHRS AFTER T&D LOSS
C TDRATMN = TDLOSMN / TDEFFMN. MULT ENERGY (TWH) DELIVERED AFTER T&D LOSSES
C           BY TDRATMN TO OBTAIN T&D ENERGY LOSS (TWH)
C HRCNT   = NUMBER OF HOURS OF SIMULATION FOR EACH GMT HOUR 1..24
C HRINFLX = INFLEXIBLE ELEC LOAD EACH DAY OF SIM (TWH) FOR EACH 1..24 GMT HOUR
C           INCLUDES INLEXIBLE LOADS UNSATISFIED BY HEAT+COLD STORAGE THAT MUST
C           BE MET IMMEDIATELY BY ELECTRICITY.
C ORIGLD  = INFLEX+FLEXIBLE (FLEXLOAD+COLDTWH+WARMTWH+FLEXH2LD) LOAD
C           EACH HOUR OF SIM (TWH) FOR EACH 1..24 GMT
C           HOURS BEFORE SHIFTING TIME OF LOAD DUE TO DEMAND RESPONSE
C HRONWIN = CUM ONSHORE WIND PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HROFFWD = CUM OFFSHORE WIND PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRROOF  = CUM ROOF PV PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRUTPV  = CUM UTIL PV PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRCSP   = CUM CSP PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRWAVE  = CUM WAVE POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C           AFTER T&D LOSSES
C HRGEOT  = CUM GEOT POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C           AFTER T&D LOSSES
C HRTIDE  = CUM TIDE POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C           AFTER T&D LOSSES
C HRHYDR  = CUM HYDRO PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C           DIVIDE BY TDEFFMN(IHYDRO) AT END OT ACCOUNT FOR T&D LOSSES
C HRSHT   = CUM SOLAR-HEAT PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRGHT   = CUM GEOTHERMAL HEAT PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C           AFTER T&D LOSSES
C HRSUPP  = CUM WIND+SOLAR+HYDRO+GEO+TIDAL+WAVE OVER YEAR (TWH)
C           FOR EACH 1..24 GMT HR
```

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C           THIS IS SUPPLY AFTER T&D LOSSES ARE TAKEN OUT
C HRTDLS  = CUM WWS-ELECTRICITY TRANS&DIST LOSS OVER YEAR (TWH)
C         + SOLAR THERMAL DISTRIBUTION LOSS OVER YEAR (TWH)
C           FOR EACH 1..24 GMT HR.
C TWHSUPPLY = TOTAL TWH OF ENERGY SUPPLIED BY WWS ELEC+HEAT DURING SIMULATION
C             AFTER T&D LOSSES ACCOUNTED FOR. THIS INCLUDES CURTAILED WIND/SOL
C EXTRACSP = CSP SOLAR (TW) THAT CAN'T BE USED IMMEDIATELY BUT THAT CAN
C            GO STRAIGHT TO CSP STORAGE
C BASHAFT   = 2050 REGIONAL DELIVERED HYDRO FOR BASELOAD AFTER T&D LOSSES (TW)
C
         ENONWIN              = CURONSH( J) * PERHRS(J)
         ENOFFWIN             = CUROFFSH(J) * PERHRS(J)
         ENROOFPV             = CUROOFPV(J) * PERHRS(J)
         ENUTILPV             = CURUTPV( J) * PERHRS(J)
         ENCSP                = CURCSP(  J) * PERHRS(J)
         ENSTCSP              = EXTRACSP(J) * PERHRS(J)
         ENWAV                = CURWAVP( J) * PERHRS(J)
         ENGEO                = CURGEOP( J) * PERHRS(J)
         ENTID                = CURTIDP( J) * PERHRS(J)
         ENHYD                = BASHAFT     * PERHRS(J)
         ENSHT                = CURSOLHT(J) * PERHRS(J)
         ENGHT                = CURGEOH( J) * PERHRS(J)
C
         HRCNT(  IGMTH,IGMTD) = HRCNT(  IGMTH,IGMTD) + PERHRS(J)
         HRINFLX(IGMTH,IGMTD) = HRINFLX(IGMTH,IGMTD) + DEMAND(J)
         ORIGLD( IGMTH,IGMTD) = ORIGLD( IGMTH,IGMTD) + DEMAND(J)
         HRONWIN(IGMTH,IGMTD) = HRONWIN(IGMTH,IGMTD) + ENONWIN
         HROFFWD(IGMTH,IGMTD) = HROFFWD(IGMTH,IGMTD) + ENOFFWIN
         HRROOF( IGMTH,IGMTD) = HRROOF( IGMTH,IGMTD) + ENROOFPV
         HRUTPV( IGMTH,IGMTD) = HRUTPV( IGMTH,IGMTD) + ENUTILPV
         HRCSP(  IGMTH,IGMTD) = HRCSP(  IGMTH,IGMTD) + ENCSP + ENSTCSP
         HRWAVE( IGMTH,IGMTD) = HRWAVE( IGMTH,IGMTD) + ENWAV
         HRGEOT( IGMTH,IGMTD) = HRGEOT( IGMTH,IGMTD) + ENGEO
         HRTIDE( IGMTH,IGMTD) = HRTIDE( IGMTH,IGMTD) + ENTID
         HRHYDR( IGMTH,IGMTD) = HRHYDR( IGMTH,IGMTD) + ENHYD
         HRSHT(  IGMTH,IGMTD) = HRSHT(  IGMTH,IGMTD) + ENSHT
         HRGHT(  IGMTH,IGMTD) = HRGHT(  IGMTH,IGMTD) + ENGHT
         HRSUPP( IGMTH,IGMTD) = HRSUPP( IGMTH,IGMTD)
     1                        + SUPPLY(J) + SUPPHT(J) + ENSTCSP
         TWHSUPPLY            = TWHSUPPLY
     1                        + SUPPLY(J) + SUPPHT(J) + ENSTCSP
C
         HRTDLS(IGMTH,IGMTD) = HRTDLS(IGMTH,IGMTD)
     1                       + TDRATMN(IONWIND)  * ENONWIN
     1                       + TDRATMN(IOFFWIND) * ENOFFWIN
     1                       + TDRATMN(IRESPV)   * ENROOFPV
     1                       + TDRATMN(IUTILPV)  * ENUTILPV
     1                       + TDRATMN(ICSPSTOR) * (ENCSP + ENSTCSP)
     1                       + TDRATMN(IWAVE)    * ENWAV
     1                       + TDRATMN(IGEOEL)   * ENGEO
     1                       + TDRATMN(ITIDAL)   * ENTID
     1                       + TDRATMN(IHYDRO)   * ENHYD
     1                       + TDRATMN(ISOLTHM)  * ENSHT
     1                       + TDRATMN(IGEOHT)   * ENGHT
         GOTO 220
        ENDIF
 216   CONTINUE
C      CONTINUE I = 1, MXLOADYR - 1
 220  CONTINUE
C     CONTINUE J = 1, IWWS
C
C ***************************************************************************
C              PRINT MAX, MIN LOADS AND RAMP RATES EACH YEAR
C ***************************************************************************
C AMAXLOAD  = MAXIMUM LOAD (TW) ANY TIME BETWEEN 1..NYEARS
C AMINLOAD  = MINIMUM LOAD (TW) ANY TIME BETWEEN 1..NYEARS
C TIMAXLOAD = HOUR OF SIMULATION OF MAXIMUM LOAD AMAXLOAD
C TIMINLOAD = HOUR OF SIMULATION OF MINIMUM LOAD AMINLOAD
C RAMPMAX   = MAX LOAD RAMP RATE (TW/HR) (UP OR DOWN) BETWEEN TWO CONSEC TIMES
C TIMAXRAMP = HOUR OF SIMULATION OF END OF GREATEST RAMP RAMPMAX
C YRLOAD    = ANNUAL AVERAGE LOAD (TW) FOR EACH 1..MXYLOAD YEAR ((2006 TO 2016)
C             FOR ELECTRICITY-ONLY LOAD DATA READ IN
C LOADYR    = ACTUAL YEAR OF LOAD DATA (2006 TO 2016)
C IYLOAD    = 1..MXYLOAD YEAR OF LOAD DATA (MXYLOAD = 11: 2006 TO 2016)
C             FOR CURRENT I=1, NYEARS YEAR OF SIMULATION
```

```
C TNONHC    = ANNUAL AVG TOTAL INFLEXIBLE LOAD (TW) THAT IS NOT HOT OR COLD LOAD
C
      WRITE(IOUT,329)
      LOADYR        = IBEGYLOAD - 1
      DO I          = 1, NYEARS
       LOADYR       = LOADYR + 1
       IYLOAD       = LOADYR - IYBEFORE
       WRITE(IOUT,129) I, LOADYR, AMAXLOAD(I), TIMAXLOAD(I),
     1                            AMINLOAD(I), TIMINLOAD(I),
     1                            RAMPMAX( I), TIMAXRAMP(I),
     1                TNONHC/YRLOAD(IYLOAD),TNONHC,YRLOAD(IYLOAD)
 129   FORMAT(I2,I5,3(0PF8.4,0PF8.1),0PF8.4,2(0PF9.5))
 329   FORMAT('# YEAR MAXLOAD(TW) TMAX(HR) MIN TMIN RAMPMX(TW/H)'
     1       ,'TRAMP TNONHC/YRLD TNONHC YRLOAD')
      ENDDO
C     ENDDO I = 1, NYEARS
C
C **********************************************************************
C                   DETERMINE IF LOAD CAN BE MATCHED
C **********************************************************************
C TIMWWS  = GMT HOURS PAST JAN. 1, 2050 (INITYEAR) AT 0 GMT FOR WWS SUPPLY DATA
C TIMLOAD = GMT HOUR OF SIMULATION (0.5 = 0-1 GMT JANUARY 1) CORRESPONDING TO
C           TIME OF LOAD DATA. VARIES FROM 0.5..NHRSIM-0.5
C BLOAD   = 2050 HOURLY INFLEXIBLE LOAD DATA (TW) FOR GRID REGION FROM LOAD DATA
C           EXTRAPOLATED TO 2050
C CLOAD   = VALUES OF BLOAD (TW) FOR EACH TIMWWS TIME INCREMENT
C
C COPY LOAD DATA (TW) TO EACH TIME THAT WWS DATA AVAILABLE. POWER IS
C INSTANTANEOUS SO NO NEED TO CHANGE UNITS.
C
      POWMXOUT    = 0.
      BATMXOUT    = 0.
      POWMXIN     = 0.
      STORH2MX    = 0.
      IGMTDLAST   = 0
      REMAINDEM   = 0.
      TLOADALL    = 0.
      TLOADFLX    = 0.
      SUPPMAX     = 0.
      JGMTHLAST   = 0
      REDFLEX     = 0.
C
C IGMTD    = 1..NDSIM GMT DAY OF SIM, ASSUMING 365-DAY YEARS AND NO LEAP YEARS
C            (1 = JAN 1 OF FIRST YEAR; 2 = JAN 2, ETC.)
C GMTHR    = 0..23 GMT HOUR OF DAY, FOR ANY DAY OF THE YEAR
C IGMTH    = 1..24 GMT HOUR OF DAY, FOR ANY DAY OF THE YEAR
C          = 1 IS FOR TIME BETWEEN 0 AND 1 GMT
C IGMTY    = 1...NYEARS YEAR OF SIMULATION. IGMTD=1 OR 365-->IGMTY=1;
C            IGMTD=366 OR 730-->IGMTY=2
C JGMTH    = 1...NHRSIM GMT HOUR OF SIMULATION. 1 IS FOR TIME BETWEEN
C            0 AND 1 GMT ON JAN 1 OF FIRST YEAR
C NHRSIM   = TOTAL NUMBER OF HOURS OF MODEL SIMULATION HERE
C
      WRITE(IOUT,208)
 208  FORMAT(/'IGMTD DEMANDNEW DEMINFLEX REMAINDEM ',
     1       'SUPPLY SUPPHT WARMTWH COLDTWH FLEXLOAD FLEXH2LD ',
     1       'FLEXLOAD+FLEXH2LD+WARMTWH+COLDTWH ',
     1       'STORCCUR STORPCUR STORBCUR STORFCUR STOROCUR STORHCUR ',
     1       'UGSTORCUR HYDROTWH H2CURSTOR CUMSHED ',
     1       'HYDISCHTW*PERHRS UTESDISCH*PERHRS/RTUGEFF ')
C
      DO 250 J    = 1, IWWS
       IF (TIMWWS(J).GT.0.AND.TIMWWS(J).LT.TIMLOAD(NHRSIM)) THEN
C
        GMTDAY    = TIMWWS(J) / 24.
        IGMTD     = INT(GMTDAY) + 1
        GMTHR     = MOD(TIMWWS(J),24.)
        IGMTH     = INT(GMTHR) + 1
        IGMTY     = INT(IGMTD/365) + 1
        JGMTH     = INT(TIMWWS(J)) + 1
C
        IF (IGMTD.GT.NDSIM.OR.JGMTH.GT.NHRSIM) THEN
         WRITE(IOUT,*)'POWERWORLD2: IGMTD>NDSIM OR JGMTH>NHRSIM ',
     1                IGMTD,NDSIM,JGMTH,NHRSIM
         STOP
```

```
       ENDIF
C
C ***************************************************************
C ADD EXTRA CSP SOLAR COLLECTED FROM MIRRORS BEYOND GENERATOR CAPACITY
C                STRAIGHT TO CSP STORAGE
C ***************************************************************
C STORCCUR = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C STORCTWH = MAX NUMBER OF TWH OF CSP STORAGE
C EXTRACSP = CSP SOLAR (TW) THAT CAN'T BE USED IMMEDIATELY BUT THAT CAN
C            GO STRAIGHT TO CSP STORAGE C RTCSPEFF = SQRT(EFFCSP)
C          = FRACTION OF ENERGY ADDED TO OR REMOVED FROM PHASE-CHANGE MATERIAL
C            IN CSP THAT IS NOT LOST DUE TO T&D LOSSES
C            APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HCSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CSP STORAGE
C            EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C            IN AND OUT OF STORAGE
C HCSTLS   = CUM ENERGY LOSS COMING OUT OF CSP STORAGE OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C HCSTLI   = CUM ENERGY LOSS GOING INTO CSP STORAGE ONLY OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C          = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C            STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C HRSHED   = CUM WIND+SOLAR CURTAILED (TWH) WHEN EXCESS SUPPLY & STORAGE FILLED
C
         EXCESS              = EXTRACSP(J) * PERHRS(J)
         STORADD             = MIN(EXCESS * RTCSPEFF, STORCTWH-STORCCUR)
         STORCCUR            = STORCCUR + STORADD
         EFFLOS              = STORADD  / RTCSPEFF - STORADD
         HCSTOR(IGMTH,IGMTD) = HCSTOR(IGMTH,IGMTD) + STORADD
         HCSTLI(IGMTH,IGMTD) = HCSTLI(IGMTH,IGMTD) + EFFLOS
         EXCESS              = EXCESS - STORADD - EFFLOS
         HRSHED(IGMTH,IGMTD) = HRSHED(IGMTH,IGMTD)+MAX(EXCESS,0.)
C
C ***************************************************************
C  ADD NEW SUPPLY HYDRO (TWH) EACH TIME STEP - LIMITED IN ANNUAL AVERAGE
C  BY CURRENT ANNUAL ENERGY SUPPLY (TWH). USE SOME OF HYDRO FOR BASELOAD
C  AND REST FOR PEAKING.
C ***************************************************************
C HYDROTWH  = CURRENT TWH OF AVAILABLE HYDROPOWER HELD IN RESERVOIRS IN REGION
C             FOR PEAKING POWER. MAX VALUE IS PKHYDMAX.  EACH TIME STEP, ADD
C             PEAKHYD*PERHRS TWH TO RESERVOIR. HYDRO SUBTRACTED AT RATE THAT VARIES
C             FROM 0 TO PKHYDISCH*PERHRS EACH TIME STEP. HYDROTWH DOES
C             NOT STORE HYDRO USED FOR BASELOAD. THAT IS STORED IN BASHYDMX
C             HYDROTWH INCLUDES ENERGY BEFORE T&D LOSSES ACCOUNTED FOR
C PEAKHYD   = 2050 HYDRO OUTPUT DELIVERED FROM TURBINE USED FOR PEAKING POWER (TW)
C             BASEHYD, PEAKHYD, AND TURBHYD ARE ALL BEFORE T&D LOSSES
C PKHYDMAX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR PEAKING BEF T&D ACCOUNTED FOR
C
         HYDROTWH  = MIN(HYDROTWH + PEAKHYD * PERHRS(J), PKHYDMAX)
C
C JGMTH     = 1...NHRSIM GMT HOUR OF SIMULATION. 1 IS FOR TIME BETWEEN
C             0 AND 1 GMT ON JAN 1 OF FIRST YEAR
C REDFLEX   = REMAINHR(LASTDAYHR) / NTIMSTEPS(JGMTH)
C           = REDUCTION (TWH) IN FLEXIBLE LOAD IN CURRENT HOUR THAT
C             WAS NOT MET WITHIN LAST MXHRDRM HOURS. CONVERT THAT FLEXIBLE
C             LOAD TO INFLEXIBLE LOAD. DIVIDE REMAINHR FROM MXHRDRM HOURS
C             PREVIOUSLY BY NTIMSTEPS FOR CURRENT HOUR SINCE NTIMSTEPS
C             IS THE NUMBER OF STEPS IN CURRENT HOUR THAT REDUCTION
C             MUST OCCUR IN
C REMAINHR  = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY,
C             FOR EACH GMT HOUR OF THE SIMULATION. THE SUM OF REMAINHR
C             OVER ALL HOURS EQUAL REMAINDEM AT ANY POINT.
C LASTDAYHR = GMT HOUR CORRESPONDING TO 24 HOURS BEFORE CURRENT HOUR
C MXHRDRM   = MAX NUMBER OF HOURS FORWARD THAT LOAD CAN BE SHIFTED BY
C             DEMAND-RESPONSE MANAGEMENT
C NTIMSTEPS = NUMBER OF J=1..IWWS TIME STEPS DURING GMT HOUR
C
        IF (JGMTH.NE.JGMTHLAST) THEN
         JGMTHLAST = JGMTH
         IF (JGMTH.GT.MXHRDRM) THEN
          LASTDAYHR = JGMTH - MXHRDRM
          REDFLEX   = REMAINHR(LASTDAYHR) / NTIMSTEPS(JGMTH)
         ELSE
          REDFLEX   = 0.
         ENDIF
```

```
       ENDIF
C
C ********************************************************************
C SPECIFY LOADS THAT CAN BE SHIFTED WITH DEMAND-RESPONSE OR SUPPLIED WITH
C STORAGE.
C ********************************************************************
C IFGATHEAT = 1: READ IN AND USE BUILDING HEATING AND COOLING ENERGY NEEDED EACH
C                TIME STEP FOR EACH COUNTRY IN wwssupworld.dat (wwssupply.xxx)
C                THIS IS USED TO SHAPE TIME-DEPENDENT HEATING/COOLING PROFILES
C                --> THIS AVOIDS USING DATA FROM heatcooldd.dat TO DO THIS
C           = 2: READ IN BUT DO NOT USE BUILDING HEATING AND COOLING ENERGY
C                INSTEAD USE HEATING-DEGREE AND COOLING-DEGREE DAY DATA
C                FROM heatcooldd.dat
C           = 0: DO NOT READ IN OR USE HEATING OR COOLING ENERGY
C                THIS IS USED ONLY WHEN PREVIOUS FORMAT W/O HEAT IS USED
C COLDTWH   = TWH OF COLD CURRENTLY NEEDED FROM STORAGE (CW-STES + PCM-ICE) OR
C             FROM CURRENT COLD PRODUCTION
C WARMTWH   = TWH OF HEAT CURRENTLY NEEDED FROM STORAGE (STORHCUR OR UGSTORCUR)
C             OR FROM CURRENT HEAT PRODUCTION
C             IT IS REALLY THE ELECTRICAL ENERGY NEEDED FOR A HEAT PUMP WITH A
C             COEFF OF PERFORMANCE CPERFORM NEEDED TO SUPPLY A LARGER
C             AMOUNT OF HEAT THAN WARMTWH
C TCOOLDAY  = LOAD ON SPECIFIC DAY (TW) FOR COOLING (AC & REFRIG)
C TWARMDAY  = LOAD ON SPECIFIC DAY OF YEAR (TW) FOR HEATING AIR AND WATER
C PERHRS    = TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C CURHLOAD  = CURRENT BUILDING HEAT LOAD (TW) FOR REGION AFTER SCALING
C             ANNUAL AVG HEAT LOAD BY CURRENT TO AVG LOAD IN GATOR-GCMOM
C CURCLOAD  = CURRENT BUILDING COLD LOAD (TW) FOR REGION AFTER SCALING
C             ANNUAL AVG COLD LOAD BY CURRENT TO AVG LOAD IN GATOR-GCMOM
C CURFLOAD  = TLOADDRM, BUT WITH COLDFLEX AND HOTFLEX CONVERTED FROM
C             ANNUAL AVERAGE NUMBERS TO TIME-DEPENDENT NUMBERS WITH SAME
C             ANNUAL AVERAGE TOTA CONVERTED FROM
C FLEXLOAD  = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C             TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C             THIS GETS SHIFTED DURING THE DAY
C             THIS DOES NOT INCLUDE SOLAR-HEAT SUPPLIED BY HW-STES OR UTES
C             OR COLD SUPPLIED BY CW-STES OR PCM-ICE
C FLEXH2LD  = 2050 FLEXIBLE LOAD (TWH) DUE TO H2 PROD/COMPRESS/STOR ADDED
C             EACH TIME INCREMENT. THE H2 IS EITHER DRAWN FROM ACCUMULATED H2
C             STORAGE FROM ANY PREVIOUS TIME OR PRODUCED FROM CURRENT ELECTRICITY
C DAYFLEX   = FLEX LOAD (TW) FROM DEMAND-RESPONSE EACH GMT DAY OF YEAR
C             DOES NOT INCLUDE COOLING LOAD, HEATING LOAD OR LOAD FOR
C             H2 PRODUCTION.
C H2FLEX    = FLEX LOAD (TW) FOR H2 PROD/COMPRESS/STORAGE. H2 LOAD FOR
C             TRANSPORT/INDUSTRY IS ASSUMED CONSTANT DURING YEAR
C H2INFLEX  = INFLEXIBLE H2 LOAD (TWH), WHICH IS ENERGY OVER CURRENT
C             TIME STEP FOR H2 NOT AVAILABLE FROM STORAGE. STARTS AT ZERO, INCREASES
C             DURING TIME STEP ONLY WHEN H2 FROM STORAGE NOT AVAILABLE.
C HCINFLEX  = INFLEXIBLE HEAT AND COLD LOAD (TWH). HEAT AND COLD LOAD
C             NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C             ELECTRICAL STORAGE. OF THE REMAINING HEAT/COLD LOAD, FRACTIONS
C             FHEATFLX, FCOLDFLX`ARE SUBJECT TO DEMAND RESPONSE AND REST MUST
C             BE SATISFIED IMMEDIATELY.
C
       IF (IFGATHEAT.EQ.1) THEN
        WARMTWH  = CURHLOAD(J) * PERHRS(J)
        COLDTWH  = CURCLOAD(J) * PERHRS(J)
        FLEXLOAD = CURFLOAD(J) * PERHRS(J)
       ELSE
        WARMTWH  = TWARMDAY(IGMTD) * PERHRS(J)
        COLDTWH  = TCOOLDAY(IGMTD) * PERHRS(J)
        FLEXLOAD = DAYFLEX( IGMTD) * PERHRS(J)
       ENDIF
C
       FLEXH2LD = H2FLEX(  IGMTD) * PERHRS(J)
       H2INFLEX = 0.
       HCINFLEX = 0.
C
C HOTBRKTWH = CURRENT INDUSTRIAL HEAT DEMAND (TWH) THAT CAN BE MET WITH
C             HI-TEMP BRICK STORAGE
C HOTINDDEM = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C
       IF (IFHEATBAT.EQ.1) THEN
        HOTBRKTWH = HOTINDDEM * PERHRS(J)
       ELSE
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```
         HOTBRKTWH = 0.
        ENDIF
C
C ORIGLD   = INFLEX+FLEXIBLE (FLEXLOAD+COLDTWH+WARMTWH+FLEXH2LD) LOAD
C            EACH HOUR OF SIM (TWH) FOR EACH 1..24 GMT
C            HOURS BEFORE SHIFTING TIME OF LOAD DUE TO DEMAND RESPONSE
C COLDHR   = TWH COLD LOAD NEEDED FROM STORAGE (CW-STES + PCM-ICE) OR
C            CURRENT PRODUCTION, EACH HOUR OF SIMULATION
C          = COLDTWH + CINFXCLD*PERHRS
C WARMHR   = TWH WARM LOAD NEEDED FROM STORAGE (STORHCUR OR UGSTORCUR)
C            OR STORED ELECTRICITY OR CUR ELECTRICITY OR HEAT EACH
C            HOUR OF SIM. = WARMTWH + CINFXHLD*PERHRS
C            IT IS REALLY THE ELECTRICAL ENERGY NEEDED FOR A HEAT PUMP WITH A
C            COEFF OF PERFORMANCE CPERFORM NEEDED TO SUPPLY WARMTH
C HOTHOUR  = CURRENT HOUR TOTAL INFLEXIBLE HOT LOAD (TW) ACROSS ALL SECTORS
C COLDHOUR = CURRENT HOUR TOTAL INFLEXIBLE COLD LOAD (TW) ACROSS ALL SECTORS
C CURCFLEX = CURRECT LOAD (TW) SUBJECT TO DRM THAT IS BUILDING COLD LOAD
C CURHFLEX = CURRECT LOAD (TW) SUBJECT TO DRM THAT IS BUILDING HEAT LOAD
C COLDFLEX = PORTION OF COLD LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C HOTFLEX  = PORTION OF WARM LOAD (TW) NOT MET BY STORAGE THAT CAN
C            BE MET BY DEMAND RESPONSE.
C HOTBRKTWH= CURRENT INDUSTRIAL HEAT DEMAND (TWH) THAT CAN BE MET WITH
C            HI-TEMP BRICK STORAGE
C
        ORIGLD(IGMTH,IGMTD) = ORIGLD(IGMTH,IGMTD)
     1                      + FLEXLOAD + COLDTWH + WARMTWH + FLEXH2LD
     1                      + HOTBRKTWH
C
        IF (IFGATHEAT.EQ.1) THEN
         COLDHR(IGMTH,IGMTD) = COLDHR(IGMTH,IGMTD) + COLDTWH
     1                       + (CINFXCLD(J) + CURCFLEX(J)) * PERHRS(J)
         WARMHR(IGMTH,IGMTD) = WARMHR(IGMTH,IGMTD) + WARMTWH
     1                       + (CINFXHLD(J) + CURHFLEX(J)) * PERHRS(J)
        ELSE
         COLDHR(IGMTH,IGMTD) = COLDHR(IGMTH,IGMTD) + COLDTWH
     1                       + (COLDHOUR(JGMTH) + COLDFLEX) * PERHRS(J)
         WARMHR(IGMTH,IGMTD) = WARMHR(IGMTH,IGMTD) + WARMTWH
     1                       + (HOTHOUR(JGMTH)  + HOTFLEX)  * PERHRS(J)
        ENDIF
C
C ***********************************************************************
C        SATISFY CURRENT H2 LOAD FROM STORED H2 IF AVAILABLE
C ***********************************************************************
C H2STOR    = CUM NET TWH ENERGY ADDED TO PRODUCING/COMPRESSING/STORING (+)
C             SUBTRAC FROM USING (-) H2 EACH 1..24 GMT HR. INCL EN FOR LEAKED H2
C H2LOAD    = CUM FLEX H2 LOAD COMING FROM H2 STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HOUR
C TWHSTORH2 = TWH OF NON-GRID H2 LOAD MET BY H2 PREVIOUSLY IN STORAGE
C TWHELECH2 = TWH OF NON-GRID H2 LOAD MET BY H2 PRODUCED FROM CURRENT ELECTRICITY
C FLEXLOAD  = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C             TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C             THIS GETS SHIFTED DURING THE DAY
C             THIS DOES NOT INCLUDE SOLAR-HEAT SUPPLIED BY HW-STES OR UTES
C             OR COLD SUPPLIED BY CW-STES OR PCM-ICE
C FLEXH2LD  = 2050 FLEXIBLE LOAD (TWH) DUE TO H2 PROD/COMPRESS/STOR ADDED
C             EACH TIME INCREMENT. THE H2 IS EITHER DRAWN FROM ACCUMULATED H2
C             STORAGE FROM ANY PREVIOUS TIME OR PRODUCED FROM CURRENT ELECTRICITY
C             FLEXH2LD IS ALWAYS < H2PEAKLD*PERHRS(J) SINCE FLEXH2LD=
C             H2FLEX*PERHRS(J)=TLOADH2*PERHRS(J)=H2PEAKLD*EUSEFACMIN*PERHRS(J)
C             AND EUSEFACMIN < 1
C TLOADFLX  = 2050 TOTAL FLEXIBLE ELEC LOAD, INCLUDING HEAT, COLD & HI-T HEAT SATISFIED BY
C             ELECTRICITY (FLEXIBLE & INFLEXIBLE); HEAT,COLD & HI-T HEAT SATISFIED BY
C             STORAGE; AND H2 LOAD (TWH), OVER SIMULATION
C
C ***********************************************************************
C                MORE H2 IN STORAGE THAN CURRENT LOAD
C ***********************************************************************
C
        IF (H2CURSTOR.GE.FLEXH2LD) THEN
         H2CURSTOR            = H2CURSTOR            - FLEXH2LD
         H2LOAD( IGMTH,IGMTD) = H2LOAD( IGMTH,IGMTD) + FLEXH2LD
         H2STOR( IGMTH,IGMTD) = H2STOR( IGMTH,IGMTD) - FLEXH2LD
         TWHSTORH2            = TWHSTORH2            + FLEXH2LD
         TLOADFLX             = TLOADFLX             + FLEXH2LD
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```
       ELSE
C
C ***********************************************************************
C       NOT ENOUGH H2 IN STORAGE --> ADD H2 LOAD TO H2INFLEX
C       THIS ELECTRICITY USED FOR ELECTROLYZERS/COMPRESSORS
C ***********************************************************************
C H2NEEDED  = H2 NEEDED (TWH) FROM CURRENT ELECTRIC POWER SUPPLY. ADD H2
C             NEEDED TO INFLEXIBLE LOAD
C H2PEAKLD  = LARGEST INSTANT NON-GRID H2 PRODUCTION LOAD (TW) ALLOWED
C             VIA ELECTROLYZERS/COMPRESSORS FOR NON-GRID H2 WHEN IMERGH2=0 OR
C             2 AND GRID PLUS NON-GRID H2 WHEN IMERGH2=1,3
C             ENSURE H2PEAKLD IS AT LEAST AS BIG AS FCCHARG WHEN IMERGH2=1
C H2INFLEX  = INFLEXIBLE H2 LOAD (TWH), WHICH IS ENERGY OVER CURRENT
C             TIME STEP FOR H2 NOT AVAILABLE FROM STORAGE. STARTS AT ZERO, INCREASES
C             DURING TIME STEP ONLY WHEN H2 FROM STORAGE NOT AVAILABLE.
C H2CURSTOR = CUR STORED H2 (TWH-ELECTRICITY USED TO PRODUCE/COMPRESS/STORE H2)
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR H2 ELECTROLYSIS+COMPRESSION OVER SIM
C H2TCUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR NON-GRID STORAGE WHEN IMERGH2=0 OR NON-GRID + GRID STORAGE
C             EHEN IMERGH2=1,3
C
         H2NEEDED             = FLEXH2LD             - H2CURSTOR
         H2LOAD( IGMTH,IGMTD) = H2LOAD( IGMTH,IGMTD) + H2CURSTOR
         H2STOR( IGMTH,IGMTD) = H2STOR( IGMTH,IGMTD) - H2CURSTOR
         TWHSTORH2            = TWHSTORH2            + H2CURSTOR
         TLOADFLX             = TLOADFLX             + H2CURSTOR
         H2INFLEX             = H2INFLEX             + H2NEEDED
         H2TCUMTWH            = H2TCUMTWH            + H2NEEDED
         H2CURSTOR            = 0.
         H2LDPEAKI            = MAX(H2LDPEAKI,H2NEEDED/PERHRS(J))
       ENDIF
C
C ***********************************************************************
C ADD EXCESS SOLAR-HOT-FLUID HEAT PRODUCED ABOVE HOT AIR/WATER DEMAND
C TO BOILERS/WATER HEATERS (HW-STES) AND UNDERGROUND UTES HEAT STORAGE
C ***********************************************************************
C EXCESSSUP = EXCESS (+) HEAT SUPPLY OVER DEMAND (TWH)
C           = SUPPHT(J) - WARMTWH
C             WHEN EXCESSSUP <0, DEMAND EXCEEDS SUPPLY AND
C             -EXCESSSUP = EXCESS DEMAND
C WARMTWH   = TWH OF HEAT CURRENTLY NEEDED FROM STORAGE (STORHCUR OR UGSTORCUR)
C             OR FROM CURRENT HEAT PRODUCTION
C             IT IS REALLY THE ELECTRICAL ENERGY NEEDED FOR A HEAT PUMP WITH A
C             COEFF OF PERFORMANCE CPERFORM NEEDED TO SUPPLY A LARGER
C             AMOUNT OF HEAT THAN WARMTWH
C SUPPHT    = CURRENT HEAT (TWH) FROM SOLAR HOT WATER OR GLYCOL SOLUTION COLLECTORS
C             OR GEOTHERMAL HEAT OVER TIME INTERVAL PERHRS - AFTER DISTRIBUTION LOSSES
C             ACCOUNTED FOR AND AFTER COLLECTOR EFFICIENCY ACCOUNTED FOR.
C
C             THE HEAT BEYOND BASE YEAR, HEAT IS
C             CONVERTED TO ELECTRICAL ENERGY ASSUMING A
C             COEFFICIENT OF PERFORMANCE CPERFORM BECAUSE THE RAW DEMAND
C             DATA IN countrystats.dat ASSUMES HEATING IS PROVIDED BY
C             HEAT PUMPS. THUS, FOR EXAMPLE, IF GEOTHERMAL PROVIDES X
C             UNITS OF HEAT, THE ELECTRICITY REQUIRED IS X / CPERFORM UNITS
C             SUPPHT CAN BE USED DIRECTLY WITH NO MORE EFFICIENCY LOSSES
C             OR SENT TO STORAGE (WITH ADDITIONAL EFFICIENCY LOSSES)
C
C             FOR HEAT IN THE BASE YEAR, THE HEAT IS KEPT AS HEAT
C             (CPERFORM=1) SINCE IEA DATABASE INCLUDES WWS HEAT FOR BASE
C             YEAR
C
C
       EXCESSSUP           = SUPPHT(J) - WARMTWH
C
C NECESSARY TO MULTIPLY MAX CHARGE RATE BY RTUGEFF HERE SINCE
C MULTIPLYING ONLY EXCESSSUP ALLOWS MORE HEAT INTO STORAGE THAN CAN
C BE PRODUCED.
C
       IF (EXCESSSUP.GT.0.) THEN
C
C ***********************************************************************
C         ADD EXCESS HEAT TO BOILERS / HOT WATER TANKS (HW-STES)
C ***********************************************************************
C HWADD    = TWH ADDED TO HW-STES STORAGE
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C HWLOSS   = TWH LOST DURING CHARGING OF HW-STES STORAGE
C HOTCHARG = MAX CHARGE RATE (TW) OF HOT WATER (HW)-STES
C            REALLY MAX CHARGE RATE OF ELECTRICITY TO
C            PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C            THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C            countrystats.dat
C RTHTESEF = SQRT(EFFHSTES).
C          = FRACTION OF ENERGY IN HW-STES ADDED TO/REMOVED FROM
C            HW-STES THAT IS NOT LOST, DUE TO T&D LOSSES
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C STORHTWH = MAX STORAGE CAPACITY (TWH) OF HW-STES STORAGE
C STORHCUR = CURRENT ENERGY (TWH) AVAILABLE IN HW-STES STORAGE
C HTSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HW-STES STORAGE
C            EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C            IN AND OUT OF HW-STES STORAGE
C HTSTLI   = CUM ENERGY LOSS COMING INTO HW-STES STORAGE ONLY OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C
         HWADD                = MIN(EXCESSSUP * RTHTESEF,
     1                             HOTCHARG  * PERHRS(J) * RTHTESEF,
     1                             STORHTWH - STORHCUR)
         STORHCUR             = STORHCUR + HWADD
         HWLOSS               = HWADD / RTHTESEF - HWADD
         HTSTOR( IGMTH,IGMTD) = HTSTOR(IGMTH,IGMTD) + HWADD
         HTSTLI( IGMTH,IGMTD) = HTSTLI(IGMTH,IGMTD) + HWLOSS
         EXCESSSUP            = MAX(EXCESSSUP - HWADD - HWLOSS,0.)
C
C ********************************************************************
C    ADD REMAINING EXCESS HEAT TO UNDERGROUND SOIL OR WATER (UTES)
C ********************************************************************
C UGADD     = TWH ADDED TO UTES STORAGE
C UGLOSS    = TWH LOST DURING CHARGING OF UTES STORAGE
C TWINUTES  = MAX CHARGE RATE (TW) OF UTES STORAGE FROM SOLAR THERMAL COLLECTORS
C RTUGEFF   = SQRT(EFFUTES)
C           = FRACTION OF ENERGY IN HEATED FLUID ADDED TO/REMOVED
C             FROM UNDERGROUND STORAGE THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTUGEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C             RTUGEFF^2=EFFUTES = OVERALL EFFIC OF HEATING SOIL WITH HEATED
C             FLUID THEN RETURNING HEAT TO FLUID IN OPPOSITE SEASON AND
C             USING THE HEATED FLUID TO HEAT AIR OR WATER.
C             EFFUTES IS EFFICIENCY AFTER EITHER FLUID HAS ALREADY BEEN HEATED
C             FROM ELECTRICITY OR SUN
C UTESTWH   = MAX STORAGE CAPACITY (TWH) UNDERGROUND SEAS HEAT STORAGE IN SOIL OR WATER
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UGSTORCUR = CURRENT ENERGY IN UNDERGROUND SOIL OR WATER STORAGE (TWH)
C             REALLY CURRENT TWH OF ELECTRICITY STORED IN UTES THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UGSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) UNDERGROUND STORAGE
C             EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN AND OUT OF UNDERGROUND STORAGE
C             REALLY TWH OF ELECTRICITY STORAGE ADDED THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UGSTLI    = CUM ENERGY LOSS COMING INTO UTES STORAGE ONLY OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C           = SAME AS UGSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C
         UGADD                = MIN(EXCESSSUP * RTUGEFF,
     1                             TWINUTES  * PERHRS(J) * RTUGEFF,
     1                              UTESTWH  - UGSTORCUR)
         UGSTORCUR            = UGSTORCUR + UGADD
         UGLOSS               = UGADD / RTUGEFF - UGADD
         UGSTOR( IGMTH,IGMTD) = UGSTOR(IGMTH,IGMTD) + UGADD
         UGSTLI( IGMTH,IGMTD) = UGSTLI(IGMTH,IGMTD) + UGLOSS
         EXCESSSUP            = MAX(EXCESSSUP-UGADD-UGLOSS,0.)
C
C CURTAIL ANY HEAT THAT CAN'T FIT INTO STORAGE
C
         HRSHED(IGMTH,IGMTD)  = HRSHED(IGMTH,IGMTD) + EXCESSSUP
C
C FLEXHEAT = FLEXIBLE HEAT LOAD (TWH) ACTUALLY SUPPLIED DURING CURRENT STEP
C            BY CURRENT SOLAR+GEOTHERMAL HEAT OR HW-STES + UTES STORAGE
C            IT IS REALLY THE ELECTRICAL ENERGY NEEDED FOR A HEAT PUMP WITH A
C            COEFF OF PERFORMANCE CPERFORM NEEDED TO SUPPLY A LARGER
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C            AMOUNT OF HEAT THAN FLEXHEAT
C WARMTWH  = TWH OF HEAT CURRENTLY NEEDED FROM STORAGE (STORHCUR OR UGSTORCUR)
C            OR FROM CURRENT HEAT PRODUCTION
C            IT IS REALLY THE ELECTRICAL ENERGY NEEDED FOR A HEAT PUMP WITH A
C            COEFF OF PERFORMANCE CPERFORM NEEDED TO SUPPLY A LARGER
C            AMOUNT OF HEAT THAN WARMTWH
C
       FLEXHEAT              = WARMTWH
C
C ***********************************************************************
C WHEN HOT AIR/WATER DEMAND EXCEEDS SOLAR-HOT-FLUID SUPPLY, DRAW FROM
C                   UNDERGROUND UTES HEAT STORAGE
C IF UTES DEPLETED, ADD REMAINING LOAD TO FLEXIBLE LOAD OBTAINED FROM
C                         OTHER STORAGE.
C ***********************************************************************
C EXCESSSUP = EXCESS (+) HEAT SUPPLY OVER DEMAND (TWH)
C           = SUPPHT(J) - WARMTWH
C             WHEN EXCESSSUP <0, DEMAND EXCEES SUPPLY AND
C             -EXCESSSUP = EXCESS DEMAND
C
       ELSE
C      ELSEIF EXCESSSUP <=0
C
C ***********************************************************************
C                   DISCHARGE FROM HW-STES STORAGE
C ***********************************************************************
C EXCESDEM = EXCESS TWH DEMAND FOR HEAT OVER SUPPLY FROM SOLAR COLLECTORS,
C            GEOTHERMAL HEAT
C RTHTESEF = SQRT(EFFHSTES).
C          = FRACTION OF ENERGY IN HW-STES ADDED TO/REMOVED FROM
C            HW-STES THAT IS NOT LOST, DUE TO T&D LOSSES
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C HTSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HW-STES STORAGE
C            EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C            IN AND OUT OF HW-STES STORAGE
C HTSTLS   = CUM ENERGY LOSSES FROM HW-STES STORAGE OVER YEAR
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C HOTDISCH = MAX DISCHARGE AND CHARGE RATE (TW) OF HOT WATER (HW)-STES
C            REALLY MAX DISCHARGE AND CHARGE RATE OF ELECTRICITY TO
C            PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C            THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C            countrystats.dat
C STORSUB  = TWH SUBTRACTED FROM STORAGE AFTER EFFIC LOSS ACCOUNTED FOR
C          = LOAD OBTAINED FROM STORAGE WITHOUT COUNTING LOSSES
C          = EXCESDEM LIMITED BY RATE OF UTES DISCHARGE
C REMSTOR  = CUR TOTAL ENERGY (TWH) REMOVED FROM STORAGE. THIS IS ENERGY
C            USED PLUS ENERGY LOST DUE TO EFFICIENCY LOSS COMING OUT OF STORAGE
C FCOLDFLX = FRACTION OF COLD LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY COLD STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C TREMHSTOR= NET EN (TWH) (NOT LOSSES) REM FROM HW-STES
C
         EXCESDEM  = -EXCESSSUP
         REMSTOR   = MIN(EXCESDEM             / RTHTESEF,
     1                   HOTDISCH * PERHRS(J) / RTHTESEF,
     1                   STORHCUR)
         STORHCUR  = MAX(STORHCUR - REMSTOR,0.)
         STORSUB   = REMSTOR   * RTHTESEF
         EXCESDEM  = EXCESDEM  - STORSUB
         TREMHSTOR = TREMHSTOR + STORSUB
C
         HTSTOR(IGMTH,IGMTD) = HTSTOR(IGMTH,IGMTD) - STORSUB
         HTSTLS(IGMTH,IGMTD) = HTSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
C
C ***********************************************************************
C                DISCHARGE FROM UTES STORAGE
C ***********************************************************************
C UGSTLS    = CUM ENERGY LOSS GOING OUT OF UNDERGROUND STORAGE OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C TREMUSTOR = NET EN (TWH) (NOT LOSSES) REM FROM UTES
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```
C
         IF (UTESDISCH.GT.0.) THEN
          REMSTOR   = MIN(EXCESDEM/RTUGEFF,
     1                    UTESDISCH * PERHRS(J) / RTUGEFF,
     1                    UGSTORCUR)
          UGSTORCUR = MAX(UGSTORCUR - REMSTOR,0.)
          STORSUB   = REMSTOR * RTUGEFF
          EXCESDEM  = EXCESDEM - STORSUB
          TREMUSTOR = TREMUSTOR + STORSUB
C
          UGSTOR(IGMTH,IGMTD) = UGSTOR(IGMTH,IGMTD) - STORSUB
          UGSTLS(IGMTH,IGMTD) = UGSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
         ENDIF
C
C ********************************************************************
C  ADD ANY PORTION OF LOAD NOT MET HERE BY STORAGE TO FLEXIBLE ELECTRIC LOAD
C  SUBJECT TO DEMAND RESPONSE (FLEXLOAD) OR INFLEXIBLE ELECTRIC LOAD
C  THAT MUST BE SATISFIED IMMEDIATELY (HCINFLEX)
C ********************************************************************
C FLEXLOAD = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C            TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C            THIS GETS SHIFTED DURING THE DAY
C            THIS DOES NOT INCLUDE SOLAR-HEAT SUPPLIED BY HW-STES OR UTES
C            OR COLD SUPPLIED BY CW-STES OR PCM-ICE
C HCINFLEX = INFLEXIBLE HEAT AND COLD LOAD (TWH). HEAT AND COLD LOAD
C            NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C            ELECTRICAL STORAGE. OF THE REMAINING HEAT/COLD LOAD, FRACTIONS
C            FHEATFLX, FCOLDFLX`ARE SUBJECT TO DEMAND RESPONSE AND REST MUST
C            BE SATISFIED IMMEDIATELY.
C FHEATFLX = FRACTION OF HEAT LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY HEAT STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C TWHEHEAT = TOTAL HEAT LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY OR
C            DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C
         FLEXLOAD  = FLEXLOAD + EXCESDEM * FHEATFLX
         HCINFLEX  = HCINFLEX + EXCESDEM * (1. - FHEATFLX)
         TWHEHEAT  = TWHEHEAT + EXCESDEM
C
C ********************************************************************
C SUBTRACT PORTION OF LOAD NOT MET HERE BY STORAGE FROM WARMTWH TO GIVE
C FLEXHEAT, WHICH IS THE PORTION OF FLEXIBLE LOAD MET BY HEATING STORAGE
C ********************************************************************
C FLEXHEAT = FLEXIBLE HEAT LOAD (TWH) ACTUALLY SUPPLIED DURING CURRENT STEP
C            BY CURRENT SOLAR+GEOTHERMAL HEAT OR HW-STES + UTES STORAGE
C
         FLEXHEAT  = WARMTWH - EXCESDEM
C
        ENDIF
C       ENDIF EXCESSSUP>0
C
C ********************************************************************
C SUPPLY DEMAND FOR COOLING (AIR CONDITIONING AND REFRIGERATION) FIRST FROM
C   COLD STORAGE (CW-STES + PCM-ICE STORAGE). IF NOT ENOUGH STORAGE,
C THEN SATISFY REST WITH CUR ELECTRICITY OR ELEC SUBJECT TO DEMAND RESPONSEE
C ********************************************************************
C STORTEM   = DEMAND FOR AIR COOLING AND REFRIGERATION (TWH)
C             STARTS = COLDTWH THEN DECREASES AS COLD DRAWN FROM STORAGE
C COLDTWH   = TWH OF COLD CURRENTLY NEEDED FROM STORAGE (CW-STES + PCM-ICE) OR
C             FROM CURRENT HEAT PRODUCTION
C STOROCUR  = CURRENT ENERGY AVAILABLE IN CW-STES + PCM-ICE STORAGE (TWH)
C RTCOLDEF  = SQRT(EFFCOLD)
C           = FRACTION OF ENERGY IN CW-STES + PCM-ICE STORAGE
C             THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C TREMOSTOR = NET EN (TWH) (NOT LOSSES) REM FROM CW-STES + PCM-ICE DURING SIM
C HOSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CW-STES+PCM-ICE
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HOSTLS    = CUM ENERGY LOSS COMING OUT OF CW-STES+PCM-ICE STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C
        STORTEM   = COLDTWH
```

```
        STORSUB   = MIN(STORTEM,STOROCUR*RTCOLDEF,TSTORCOOL*PERHRS(J))
        STORTEM   = STORTEM   - STORSUB
        REMSTOR   = STORSUB   / RTCOLDEF
        TREMOSTOR = TREMOSTOR + STORSUB
        STOROCUR            = STOROCUR - REMSTOR
        HOSTOR(IGMTH,IGMTD) = HOSTOR(IGMTH,IGMTD) - STORSUB
        HOSTLS(IGMTH,IGMTD) = HOSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
C
C ***********************************************************************
C  ADD ANY PORTION OF LOAD NOT MET HERE BY STORAGE TO FLEXIBLE ELECTRIC LOAD
C  SUBJECT TO DEMAND RESPONSE (FLEXLOAD) OR INFLEXIBLE ELECTRIC LOAD
C  THAT MUST BE SATISFIED IMMEDIATELY (HCINFLEX)
C ***********************************************************************
C FLEXLOAD = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C            TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C            THIS GETS SHIFTED DURING THE DAY
C            THIS DOES NOT INCLUDE SOLAR-HEAT SUPPLIED BY HW-STES OR UTES
C            OR COLD SUPPLIED BY CW-STES OR PCM-ICE
C HCINFLEX = INFLEXIBLE HEAT AND COLD LOAD (TWH). HEAT AND COLD LOAD
C            NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C            ELECTRICAL STORAGE. OF THE REMAINING HEAT/COLD LOAD, FRACTIONS
C            FHEATFLX, FCOLDFLX`ARE SUBJECT TO DEMAND RESPONSE AND REST MUST
C            BE SATISFIED IMMEDIATELY.
C FCOLDFLX = FRACTION OF COLD LOAD THAT IS FLEXIBLE (SUBJECT TO DEMAND RESPONSE)
C            IF IT CAN'T BE SUPPLIED IN CURRENT TIME STEP BY COLD STORAGE
C            REMAIN LOAD INFLEXIBLE & MUST BE SUPPLIED IMMEDIATELY BY ELECTRICITY
C TWHECOLD = TOTAL COLD LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY OR
C            DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C FLEXCOLD = FLEXIBLE COLD LOAD (TWH) ACTUALLY SUPPLIED DURING CURRENT STEP
C            BY CW-STES + PCM-ICE STORAGE
C
        FLEXLOAD  = FLEXLOAD + STORTEM * FCOLDFLX
        HCINFLEX  = HCINFLEX + STORTEM * (1. - FCOLDFLX)
        TWHECOLD  = TWHECOLD + STORTEM
        FLEXCOLD  = STORSUB
C
C ***********************************************************************
C SUPPLY HI-TEMP INDUSTRIAL HEAT DEMAND FROM FIREBRICK STORAGE FIRST
C IF FIREBRICK STORAGE EXHAUSTED, SPLIT REMAINING DEMAND INTO FLEXIBLE
C AND INFLEXIBLE DEMAND AND ADD TO ELECTRICITY LOAD.
C ***********************************************************************
C BRSTORCUR = CURRENT ENERGY IN BRICK IND HEAT STORAGE (TWH)
C STOHBTWH  = MAX STORAGE CAPACITY (TWH-THERMAL) OF BRICK HEAT BATTERY STORAGE
C RTHBTEFF  = SQRT(EFFHTBAT)
C           = FRACTION OF ENERGY IN HEAT BATTERY STORAGE
C             THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C             APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C HBTDISCH  = MAX DISCHARGE RATE (TW-TH) OF FIREBRICK BATTERIES
C HBTCHARG  = MAX CHARGE RATE (TW-AC) OF FIREBRICK BATTERIES
C           = 3.5 X MAX DISCHARGE RATE FOR RHB300 FOR RONDO DATASHEET
C             MAX CHARGE RATE IS 70 MW-AC; MAX DISCH RATE IS 20 MW-TH
C FRCINDHT  = FRACTION OF INDUSTRIAL LOAD THAT IS HI-T, CHEM, OR ELEC PROCS
C HOTINDDEM = INDUSTRIAL DEMAND (TW) THAT CAN BE MET WITH HI-TEMP BRICK STORAGE
C HOTBRKTWH = CURRENT INDUSTRIAL HEAT DEMAND (TWH) THAT CAN BE MET WITH
C             HI-TEMP BRICK STORAGE
C BRSTOR    = CUM USABLE NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HI-T BRICK
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN & OUT OF STORAGE OR LOST FROM STORAGE DUE TO CONDUCTION
C BRSTLI    = CUM ENERGY LOSS COMING INTO BRICK STORAGE ONLY OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C           = SAME AS BRSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C BRSTLS    = CUM ENERGY LOSS GOING OUT OF BRICK STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C TBRICKTWH = CUM ENERGY (TWH) OVER SIM SUPPLIED FOR HI-T INDUSTRIAL HEATING FROM
C             BRICK STORAGE. DOES NOT INCLUDED LOSSES. JUST SUPPLIES
C
        EXCESDEM  = HOTBRKTWH
        REMSTOR   = MIN(EXCESDEM            / RTHBTEFF,
     1                  HBTDISCH * PERHRS(J) / RTHBTEFF,
     1                  BRSTORCUR)
        BRSTORCUR = MAX(BRSTORCUR - REMSTOR,0.)
        STORSUB   = REMSTOR * RTHBTEFF
        EXCESDEM  = EXCESDEM - STORSUB
        TBRICKTWH = TBRICKTWH + STORSUB
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C
         BRSTOR(IGMTH,IGMTD) = BRSTOR(IGMTH,IGMTD) - STORSUB
         BRSTLS(IGMTH,IGMTD) = BRSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
C
C ***********************************************************************
C  ADD ANY PORTION OF HI-T IND HEAT LOAD NOT MET HERE BY BRICK STORAGE
C  TO FLEXIBLE ELECTRIC LOAD SUBJECT TO DEMAND RESPONSE (FLEXLOAD)
C  OR INFLEXIBLE ELECTRIC LOAD THAT MUST BE SATISFIED IMMEDIATELY (HCINFLEX)
C ***********************************************************************
C FLEXLOAD  = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C             TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C             THIS GETS SHIFTED DURING THE DAY
C HCINFLEX  = INFLEXIBLE HEAT AND COLD LOAD (TWH). HEAT AND COLD LOAD
C             NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C             ELECTRICAL STORAGE.
C EXCESDEM  = HI-T IND HEAT DEMAND (TWH) NOT SATISFIED BY HI-T STORAGE
C             SO NOW MUST BE MET BY ELECTRICITY
C FRCIHFLEX = FRACTION OF INDUSTRIAL LOAD FOR HI-T, CHEM, OR ELEC PROCS
C             THAT CAN BE MET BY HI-T BRICK STORAGE BUT IS NOT MET WITH
C             SUCH STORAGE SO BECOMES FLEXIBLE (THE REST BECOMES
C             INFLEXIBLE LOAD). APPLIES ONLY WHEN IFHEATBAT=1
C             WHEN IFHEATBAT=1, ALL HEAT NOT SATISFIED BY BRICK STORAGE
C             IS ASSIGNED AS EITHER FLEXIBLE OR INFLEXIBLE, AND ADDED
C             TO FLEX OR INFLEXIBLE DEMAND THAT MUST BE MET WITH
C             ELECTRICITY. THE FLEXIBLE FRACTION IS FRCIHFLEX
C TWHEHIGHT = TOTAL HI-T IND LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY
C             OR DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C HITFROMST = HI-T LOAD (TWH) SUPPLIED DURING CURRENT STEP BY STORAGE
C
         FLEXLOAD  = FLEXLOAD + EXCESDEM * FRCIHFLEX
         HCINFLEX  = HCINFLEX + EXCESDEM * (1. - FRCIHFLEX)
         TWHEHIGHT = TWHEHIGHT + EXCESDEM
         HITFROMST = STORSUB
C
C ***********************************************************************
C REMOVE HEAT FROM HI-T HEAT STORAGE DUE TO HEAT CONDUCTION
C ***********************************************************************
C DISSIPLOS = TWH LOSS FROM HI-T BRICK STORAGE DUE TO CONDUCTIVE LOSS
C HDISSIP   = RATE HEAT DISSIP (FRAC/HR) FROM HI-T FIREBRICKS DUE TO CONDUCTION
C           = 1%/DAY FROM RONDO DATA SHEET
C           = 0.00041667/HOUR
C PERHRS    = TIME INCREMENT (HOURS) FOR EACH WWS SUPPLY TIME INTERVAL
C BRSTORCUR = CURRENT ENERGY IN BRICK IND HEAT STORAGE (TWH)
C BRSTOR    = CUM USABLE NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HI-T BRICK
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN & OUT OF STORAGE OR LOST FROM STORAGE DUE TO CONDUCTION
C BRSTLS    = CUM ENERGY LOSS GOING OUT OF BRICK STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C
         DISSIPLOS           = BRSTORCUR * HDISSIP * PERHRS(J)
         BRSTORCUR           = MAX(BRSTORCUR - DISSIPLOS,0.)
         BRSTLS(IGMTH,IGMTD) = BRSTLS(IGMTH,IGMTD) + DISSIPLOS
C
C ***********************************************************************
C                    SUM SOME VARIABLES FOR PRINTING
C ***********************************************************************
C HRFLXLD  = CUM FLEX LOAD MET EACH DAY OF YEAR (TWH/H=TW) FOR EACH 1..24 GMT HOUR
C            AFTER DEMAND-RESPONSE MANAGEMENT ACCOUNTED FOR.
C            INLCLUDES FLEXIBLE LOAD SUPPLIED BY COLD STORAGE, HEAT STORAGE,
C            HI-T IND HEAT STORAGE, SOLAR+GEOTHERMAL HEAT, AND ALL ELECTRICITY
C TWHSHEAT = TOTAL LOAD (TWH) MET BY HEAT STORAGE (HW-STES+UTES) DURING SIM
C          = SUM OF FLEXHEAT OVER SIMULATION
C            REMAINING HEAT LOAD IS MET BY ELECTRICITY
C TWHSCOLD = TOTAL LOAD (TWH) MET BY COLD STORAGE (CW-STES+PCM-ICE) DURING SIM
C          = SUM OF FLEXCOLD OVER SIMULATION
C            REMAINING COLD LOAD IS MET BY ELECTRICITY
C TWHSHIGHT= TOTAL LOAD (TWH) MET BY HI-T BRICK STORAGE DURING SIM
C          = SUM OF HITFROMST OVER SIMULATION
C            REMAINING HI-T LOAD IS MET BY ELECTRICITY
C TLOADALL = 2050 TOTAL INFLEXIBLE + FLEXIBLE ELEC LOAD + LOAD SUBJECT TO HEAT
C            AND COLD AND HI-T HEAT STORAGE, BUT NOT H2 LOAD (TWH), OVER SIMULATION
C TLOADFLX = 2050 TOTAL FLEXIBLE ELEC LOAD, INCLUDING HEAT, COLD & HI-T HEAT SATISFIED BY
C            ELECTRICITY (FLEXIBLE & INFLEXIBLE); HEAT,COLD & HI-T HEAT SATISFIED BY
C            STORAGE; AND H2 LOAD (TWH), OVER SIMULATION
C HCINFLEX = INFLEXIBLE HEAT AND COLD LOAD (TWH). HEAT AND COLD LOAD
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C            NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C            ELECTRICAL STORAGE. OF THE REMAINING HEAT/COLD LOAD, FRACTIONS
C            FHEATFLX, FCOLDFLX`ARE SUBJECT TO DEMAND RESPONSE AND REST MUST
C            BE SATISFIED IMMEDIATELY.
C FLEXHEAT = FLEXIBLE HEAT LOAD (TWH) ACTUALLY SUPPLIED DURING CURRENT STEP
C            BY CURRENT SOLAR+GEOTHERMAL HEAT OR HW-STES + UTES STORAGE
C FLEXCOLD = FLEXIBLE COLD LOAD (TWH) ACTUALLY SUPPLIED DURING CURRENT STEP
C            BY CW-STES + PCM-ICE STORAGE
C FLEXLOAD = 2050 FLEXIBLE LOAD (TWH) ADDED EACH TIME INCREMENT
C            TO BE POWERED BY ELECTRICITY SUBJECT TO DEMAND RESPONSE.
C            THIS GETS SHIFTED DURING THE DAY
C            THIS DOES NOT INCLUDE SOLAR-HEAT SUPPLIED BY HW-STES OR UTES
C            OR COLD SUPPLIED BY CW-STES OR PCM-ICE
C HITFROMST = HI-T LOAD (TWH) SUPPLIED DURING CURRENT STEP BY STORAGE
C
       HRFLXLD(IGMTH,IGMTD) = HRFLXLD(IGMTH,IGMTD) + FLEXHEAT+FLEXCOLD
     1                                             + HITFROMST
          TWHSHEAT          = TWHSHEAT             + FLEXHEAT
          TWHSCOLD          = TWHSCOLD             + FLEXCOLD
          TWHSHIGHT         = TWHSHIGHT            + HITFROMST
          TLOADALL          = TLOADALL + DEMAND(J) + FLEXLOAD+HCINFLEX
     1                                             + FLEXHEAT+FLEXCOLD
     1                                             + HITFROMST
          TLOADFLX          = TLOADFLX             + FLEXLOAD+HCINFLEX
     1                                             + FLEXHEAT+FLEXCOLD
     1                                             + HITFROMST
C
C **********************************************************************
C  PUT LOAD SUBJECT TO DEMAND RESPONSE (DAYFLEX)
C  + HEAT LOAD NOT MET BY STORAGE SUBJECT TO DEMAND RESPONSE
C  + COLD LOAD NOT MET BY STORAGE SUBJECT TO DEMAND RESPONSE
C **********************************************************************
C REMAINDEM = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY.
C REMAINHR  = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY,
C             FOR EACH GMT HOUR OF THE SIMULATION. THE SUM OF REMAINHR
C             OVER ALL HOURS EQUAL REMAINDEM AT ANY POINT.
C
       REMAINDEM        = REMAINDEM        + FLEXLOAD
       REMAINHR( JGMTH) = REMAINHR(JGMTH)  + FLEXLOAD
C
C **********************************************************************
C CONVERT FLEXIBLE LOADS THAT HAVE NOT BEEN SATISFIED FROM CURRENT SUPPLY
C OR STORAGE TO INFLEXIBLE LOADS AND ENSURE THEY ARE MET IMMEDIATELY.
C **********************************************************************
C DEMANDNEW  = TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C DEMAND     = CURRENT ENERGY INFEXIBLE DEMAND OVER TIME INTERVAL PERHRS (TWH)
C REMAINDEM  = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY.
C REMAINHR   = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY,
C              FOR EACH GMT HOUR OF THE SIMULATION. THE SUM OF REMAINHR
C              OVER ALL HOURS EQUAL REMAINDEM AT ANY POINT.
C NTIMSTEPS  = NUMBER OF J=1..IWWS TIME STEPS DURING GMT HOUR
C              DIVIDE REMAINHR BY NTIMSTEPS(IGMTH) SINCE OTHERWISE
C              IF THERE ARE FEWER TIME STEPS CURRENT HOUR THAN 24
C              HOURS PREVIOUSLY, NOT ALL FLEX LOAD FROM 24 HOURS AGO REMOVED.
C DEMINFLEX  = INFLEXIBLE DEMAND (TWH) PLUS FLEXILE DEMAND THAT HAS NOT YET
C              BEEN MET IN LAST DAY
C ADDINFLEX  = TWH OF FLEXIBLE DEMAND FROM 24 HOURS PREVIOUS THAT MUST
C              BE SATISFIED CURRENT TIME STEP THUS BECOMES INFLEXIBLE.
C LASTDAYHR  = GMT HOUR CORRESPONDING TO 24 HOURS BEFORE CURRENT TIME
C REDFLEX    = REMAINHR(LASTDAYHR) / NTIMSTEPS(JGMTH)
C            = REDUCTION (TWH) IN FLEXIBLE LOAD IN CURRENT HOUR THAT
C              WAS NOT MET WITHIN LAST 24 HOURS. CONVERT THAT FLEXIBLE
C              LOAD TO INFLEXIBLE LOAD. DIVIDE REMAINHR FROM 24 HOURS
C              PREVIOUSLY BY NTIMSTEPS FOR CURRENT HOUR SINCE NTIMSTEPS
C              IS THE NUMBER OF STEPS IN CURRENT HOUR THAT REDUCTION
C              MUST OCCUR IN
C MXHRDRM    = MAX NUMBER OF HOURS FORWARD THAT LOAD CAN BE SHIFTED BY
C              DEMAND-RESPONSE MANAGEMENT
C HRFLXLD    = CUM FLEXIBLE LOAD EACH DAY OF YEAR (TWH) FOR EACH 1..24 GMT HOUR
C              AFTER DEMAND-RESPONSE MANAGEMENT ACCOUNTED FOR.
C              INLCLUDES FLEXIBLE LOAD SUPPLIED BY COLD STORAGE, HEAT STORAGE,
C              SOLAR+GEOTHERMAL HEAT, AND ALL ELECTRICITY
C
C CASES WHERE NOT USING DEMAND-RESPONSE - ALL POWER SATISFIED IMMEDIATELY
C
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        IF (MXHRDRM.EQ.0) THEN
         ADDINFLEX            = REMAINHR(JGMTH)
         DEMINFLEX            = DEMAND(J)            + ADDINFLEX
         REMAINDEM            = 0.
         REMAINHR(JGMTH)      = 0.
         HRFLXLD(IGMTH,IGMTD) = HRFLXLD(IGMTH,IGMTD) + ADDINFLEX
C
C HOUR OF SIMULATION BEYOND FIRST MXHRDRM HOURS
C
        ELSEIF (JGMTH.GT.MXHRDRM) THEN
         LASTDAYHR            = JGMTH - MXHRDRM
         ADDINFLEX            = MIN(REDFLEX,REMAINHR(LASTDAYHR))
         DEMINFLEX            = DEMAND(J)            + ADDINFLEX
         REMAINDEM            = REMAINDEM            - ADDINFLEX
         REMAINHR(LASTDAYHR)  = REMAINHR(LASTDAYHR)  - ADDINFLEX
         HRFLXLD(IGMTH,IGMTD) = HRFLXLD(IGMTH,IGMTD) + ADDINFLEX
C
C FIRST MXHRDRM HOURS
C
        ELSE
         DEMINFLEX = DEMAND(J)
        ENDIF
C
C ***********************************************************************
C   ADD INFLEXIBLE HEAT & COLD LOAD NOT AVAILABLE FROM STORAGE TO
C                    INFLEXIBLE ELECTRICAL LOAD
C ***********************************************************************
C DEMINFLEX = INFLEXIBLE DEMAND (TWH) PLUS FLEXILE DEMAND THAT HAS NOT YET
C             BEEN MET IN LAST DAY
C HRINFLX   = INFLEXIBLE ELEC LOAD EACH DAY OF SIM (TWH) FOR EACH 1..24 GMT HOUR
C             INCLUDES INLEXIBLE LOADS UNSATISFIED BY HEAT+COLD+HI-T HEAT STORAGE
C             THAT MUST BE MET IMMEDIATELY BY ELECTRICITY.
C HCINFLEX  = INFLEXIBLE HEAT, COLD, & HI-T HEAT LOAD (TWH). HEAT AND COLD LOAD
C             NOT SATISFIED BY HEAT OR COLD STORAGE MUST BE SATISFIED BY
C             ELECTRICAL STORAGE. OF THE REMAINING HEAT/COLD LOAD, FRACTIONS
C             FHEATFLX, FCOLDFLX`ARE SUBJECT TO DEMAND RESPONSE AND REST MUST
C             BE SATISFIED IMMEDIATELY.
C
        DEMINFLEX            = DEMINFLEX            + HCINFLEX
        HRINFLX(IGMTH,IGMTD) = HRINFLX(IGMTH,IGMTD) + HCINFLEX
C
C ***********************************************************************
C ADD H2 LOAD NOT AVAILABLE FROM STORAGE TO INFLEXIBLE ELECTRICAL LOAD
C ***********************************************************************
C H2INFLEX  = INFLEXIBLE H2 LOAD (TWH), WHICH IS ENERGY OVER CURRENT
C             TIME STEP FOR H2 NOT AVAILABLE FROM STORAGE. STARTS AT ZERO, INCREASES
C             DURING TIME STEP ONLY WHEN H2 FROM STORAGE NOT AVAILABLE.
C TWHELECH2 = TWH OF NON-GRID H2 LOAD MET BY H2 PRODUCED FROM CURRENT ELECTRICITY
C DEMINFLEX = INFLEXIBLE DEMAND (TWH)
C DEMANDNEW = TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C
        DEMINFLEX            = DEMINFLEX            + H2INFLEX
        H2LOAD( IGMTH,IGMTD) = H2LOAD( IGMTH,IGMTD) + H2INFLEX
        TWHELECH2            = TWHELECH2            + H2INFLEX
C
C DEMANDNEW = TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C REMAINDEM = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET
C SUPPMAX   = MAX TW OF WIND+SOLAR POWER SUPPLIED ANY TIME DURING YEAR
C SUPPLY    = CURRENT WIND AND SOLAR ENERGY SUPPLY OVER TIME INTERVAL PERHRS (TWH)
C             AFTER T&D LOSSES ACCOUNTED FOR
C
        DEMANDNEW = DEMINFLEX + REMAINDEM
        SUPPMAX   = MAX(SUPPLY(J)/PERHRS(J),SUPPMAX)
C
C ***********************************************************************
C  CALCULATE DIFF BETWEEN PEAK 30-S AND HOURLY AVG SUPPLY & DEMAND
C ***********************************************************************
C TOTSUPP   = TOTAL SUPPLY OF ELECTRICITY+HEAT (TWH) DURING IGMTD INTERVAL
C TOTDEMD   = TOTAL DEMAND FOR ELECTRICITY+HEAT+COLD+H2 (TWH) DURING IGMTD INTERVAL
C             DOES NOT INCLUDE T&D LOSSES, CURTAILED ENERGY, OR ENERGY GOING
C             INTO STORAGE OR ENERGY LOSSES IN & OUT OF STORAGE
C SUPTOT    = CURRENT ELECTRICITY + HEAT SUPPLY (TWH)
C SUPPLY    = CURRENT WIND AND SOLAR ENERGY SUPPLY OVER TIME INTERVAL PERHRS (TWH)
C             AFTER T&D LOSSES ACCOUNTED FOR
C SUPPHT    = CURRENT HEAT (TWH) FROM SOLAR HOT WATER OR GLYCOL SOLUTION COLLECTORS
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C             OR GEOTHERMAL HEAT OVER TIME INTERVAL PERHRS - AFTER DISTRIBUTION LOSSES
C             ACCOUNTED FOR AND AFTER COLLECTOR EFFICIENCY ACCOUNTED FOR.
C ENSTCSP   = EXCESS ENERGY (TWH) GEN BY CSP GOING DIRECT TO STORAGE AFTER T&D LOSS
C DEMTOT    = CURRENT FLEX+INFLEX ELEC+HEAT+COLD+H2 DEMAND FOR END USES (TWH)
C             DOES NOT INCLUDE T&D LOSSES, CURTAILED ENERGY, OR ENERGY GOING
C             INTO STORAGE OR ENERGY LOSSES IN & OUT OF STORAGE
C FLEXH2LD  = 2050 FLEXIBLE LOAD (TWH) DUE TO H2 PROD/COMPRESS/STOR ADDED
C             EACH TIME INCREMENT. THE H2 IS EITHER DRAWN FROM ACCUMULATED H2
C             STORAGE FROM ANY PREVIOUS TIME OR PRODUCED FROM CURRENT ELECTRICITY
C H2INFLEX  = INFLEXIBLE H2 LOAD (TWH), WHICH IS ENERGY OVER CURRENT
C             TIME STEP FOR H2 NOT AVAILABLE FROM STORAGE. STARTS AT ZERO, INCREASES
C             DURING TIME STEP ONLY WHEN H2 FROM STORAGE NOT AVAILABLE.
C HRCOUNT   = COUNT OF THE NUMBER OF HOURS PER IGMTD TIME INTERVAL
C PKSUPE    = PEAK SUPPLY OF ELECTRICITY (TW) AMONG ANY OF 120 30-SECOND INTERVALS
C             WITHIN EACH IGMTD TIME INTERVAL
C PKDEME    = PEAK DEMAND FOR ELECTRIC+HEAT+COLD+H2 (TW) AMONG ANY OF 120 30-S INTERVALS
C             WITHIN EACH IGMTD TIME INTERVAL
C
        SUPTOT             = SUPPLY(J) + SUPPHT(J) + ENSTCSP
C       DEMTOT             = DEMAND(J) + FLEXLOAD
C       DEMTOT             = HCINFLEX  + FLEXHEAT + FLEXCOLD
C       DEMTOT             = FLEXH2LD  + H2INFLEX
        DEMTOT             = DEMAND(J) + FLEXLOAD  + HCINFLEX
     1                     + FLEXHEAT  + FLEXCOLD  + FLEXH2LD + H2INFLEX
C
        TOTSUPP(IGMTH,IGMTD) = TOTSUPP(IGMTH,IGMTD) + SUPTOT
        TOTDEMD(IGMTH,IGMTD) = TOTDEMD(IGMTH,IGMTD) + DEMTOT
        HRCOUNT(IGMTH,IGMTD) = HRCOUNT(IGMTH,IGMTD) + PERHRS(J)
C
        PKSUPE(IGMTH,IGMTD)=MAX(PKSUPE(IGMTH,IGMTD),SUPTOT/PERHRS(J))
        PKDEME(IGMTH,IGMTD)=MAX(PKDEME(IGMTH,IGMTD),DEMTOT/PERHRS(J))
        ADDDEM    = 0.
C
C ***********************************************************************
C                     PRINT OUT A FEW VARIABLES
C ***********************************************************************
C DEMANDNEW = TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C DEMINFLEX = INFLEXIBLE DEMAND (TWH)
C REMAINDEM = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET
C DEMAND    = CURRENT ENERGY INFEXIBLE DEMAND OVER TIME INTERVAL PERHRS (TWH)
C SUPPLY    = CURRENT WIND AND SOLAR ENERGY SUPPLY OVER TIME INTERVAL PERHRS (TWH)
C             AFTER T&D LOSSES ACCOUNTED FOR
C STORCCUR  = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C STOROCUR  = CURRENT ENERGY AVAILABLE IN CW-STES+PCM-ICE STORAGE (TWH)
C STORBCUR  = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C
        IF (IGMTD.NE.IGMTDLAST) THEN
         IGMTDLAST = IGMTD
         WRITE(IOUT,210) IGMTD, DEMANDNEW, DEMINFLEX, REMAINDEM,
     1                   SUPPLY(J), SUPPHT(J), WARMTWH, COLDTWH,
     1                   FLEXLOAD, FLEXH2LD,
     1                   FLEXLOAD+FLEXH2LD+WARMTWH+COLDTWH,
     1                   STORCCUR, STORPCUR, STORBCUR, STORFCUR,
     1                   STOROCUR, STORHCUR, UGSTORCUR,
     1                   HYDROTWH, H2CURSTOR, CUMSHED,
     1                   HYDISCHTW*PERHRS(J),
     1                   UTESDISCH*PERHRS(J)/RTUGEFF
 210     FORMAT('XGMTD ',I5,19(1X,0PF10.5),4(1X,0PF11.5))
        ENDIF
C
C ***********************************************************************
C       HIGHER INFLEXIBLE DEMAND THAN SUPPLY, THEN DRAW FROM STORAGE
C               IF DRAW TOO MUCH, THEN STOP PROGRAM
C  IN THIS CASE, REMAINING FLEXIBLE LOAD (REMAINDEM) IS CARRIED FORWARD
C                       TO NEXT TIME STEP
C ***********************************************************************
C DEMAND    = CURRENT ENERGY INFLEXIBLE DEMAND OVER TIME INTERVAL PERHRS (TWH)
C DEMINFLEX = INFLEXIBLE DEMAND PLUS FLEXIBLE DEMAND THAT HAS NOT YET
C             BEEN MET IN LAST DAY
C
        IF (DEMINFLEX.GT.SUPPLY(J)) THEN
C
C ***********************************************************************
C SATISFY EXCESS INFLEXIBLE+FLEXIBLE LOAD WITH CSP, PHS, HYDRO
C THEN BATTERIES. SATISFY INFLEXIBLE LOAD FIRST.
```

```
C ***********************************************************************
C DEMANDNEW = TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C EXCESIN   = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C
         STORTEM  = DEMANDNEW - SUPPLY(J)
         EXCESIN  = DEMINFLEX - SUPPLY(J)
C
C ***********************************************************************
C            SATISFY INFLEXIBLE LOAD FIRST FROM CSP STORAGE
C ***********************************************************************
C REMSTOR   = CUR TOTAL ENERGY (TWH) REMOVED FROM STORAGE. THIS IS ENERGY
C             USED PLUS ENERGY LOST DUE TO EFFICIENCY LOSS COMING OUT OF STORAGE
C STORSUB   = TWH SUBTRACTED FROM STORAGE AFTER EFFIC LOSS ACCOUNTED FOR
C STORCCUR  = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C TREMCSTOR = NET EN (TWH) (NOT LOSSES) REM FROM CSP STORAGE DURING SIM
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C           = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C CSPDIFF   = DIFFERENCE (TW) BETWEEN MAX CSP DISCHARGE RATE AND CSP
C             PRODUCED DURING CURRENT TIME STEP ALREADY DISCHARGED DIRECTLY
C             (NOT THRU STORAGE) DURING CURRENT TIME STEP.
C CURCSP    = CURRENT SOLAR POWER (TW) EXTRACTED FROM CSP AFTER T&D LOSSES
C             AFTER CSP BEYOND CUR CSP DISCHARGE RATE (EXTRACSP) PUT IN STORAGE
C RTCSPEFF  = SQRT(EFFCSP)
C           = FRACTION OF ENERGY ADDED TO OR REMOVED FROM PHASE-CHANGE MATERIAL
C             IN CSP THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HCSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CSP STORAGE
C             EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN AND OUT OF STORAGE
C HCSTLS    = CUM ENERGY LOSS COMING OUT OF CSP STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C
         CSPDIFF   = MAX(CSPDISCH - CURCSP(J),0.)
         STORSUB   = MIN(STORTEM,STORCCUR*RTCSPEFF,CSPDIFF*PERHRS(J))
         STORTEM   = STORTEM   - STORSUB
         REMSTOR   = STORSUB   / RTCSPEFF
         TREMCSTOR = TREMCSTOR + STORSUB
C
C ***********************************************************************
C      IF CSP STORAGE EXCEEDS INFLEXIBLE LOAD BEYOND SUPPLY THAT
C WILL BE MET WITH CURRENT WWS PRODUCTION (EXCESIN), THEN REDUCE
C REMAINDEM, WHICH TRACKS FLEXIBLE LOAD STILL NEEDED, AND ADD THE
C DIFFERENCE TO ADDDEM, WHICH WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C ***********************************************************************
C REMFLEX   = FLEXIBLE DEMAND (TWH) THAT CAN BE SATISFIED HERE BY CSP STORAGE
C REMAINDEM = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY.
C EXCESIN   = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C ADDDEM    = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C             IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C             THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C POWMXOUT  = MAX POWER (TW) TAKEN OUT OF ELEC STORAGE (INCLUDING LOSSES)
C POWMXIN   = MAX POWER (TW) ADDED TO ELEC STORAGE (AFTER LOSSES SUBTRACTED)
C
         IF (STORSUB.GT.EXCESIN) THEN
          REMFLEX   = STORSUB   - EXCESIN
          REMAINDEM = REMAINDEM - REMFLEX
          ADDDEM    = ADDDEM    + REMFLEX
         ENDIF
C
         EXCESIN    = MAX(EXCESIN - STORSUB,0.)
C
C REDUCE AVAILABLE CSP STORAGE
C
         STORCCUR            = STORCCUR - REMSTOR
         HCSTOR(IGMTH,IGMTD) = HCSTOR(IGMTH,IGMTD) - STORSUB
         HCSTLS(IGMTH,IGMTD) = HCSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
         POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
C
C ***********************************************************************
C               ANY REMAINING INFLEXIBLE LOAD FROM BATTERIES
C ***********************************************************************
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
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```
C TREMBSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM BATTERIES DURING SIM
C TDISCHBAT = TOTAL EN (TWH) (INCLUDING LOSSES) REMOVED FROM BAT DURING SIM
C RTBATEFF  = SQRT(EFFBAT)
C           = FRACTION OF ENERGY IN BATTERY STORAGE
C             THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C             APPLY RTBATEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HBSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) BATTERY
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HBSTLS    = CUM ENERGY LOSS COMING OUT OF BATTERY STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C STORBCUR  = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C
         IF (STORTEM.GT.0.) THEN
          STORSUB   = MIN(STORTEM,STORBCUR*RTBATEFF,BATDISCH*PERHRS(J))
          STORTEM   = STORTEM   - STORSUB
          REMSTOR   = STORSUB   / RTBATEFF
          TREMBSTOR = TREMBSTOR + STORSUB
          TDISCHBAT = TDISCHBAT + REMSTOR
C
C REMFLEX = FLEXIBLE DEMAND (TWH) THAT CAN BE SATISFIED HERE BY BATTERY STORAGE
C EXCESIN = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C
          IF (STORSUB.GT.EXCESIN) THEN
           REMFLEX   = STORSUB   - EXCESIN
           REMAINDEM = REMAINDEM - REMFLEX
           ADDDEM    = ADDDEM    + REMFLEX
          ENDIF
C
          EXCESIN    = MAX(EXCESIN - STORSUB,0.)
C
C REDUCE AVAILABLE BATTERY STORAGE
C  POWMXOUT = MAX POWER (TW) TAKEN OUT OF ALL ELEC STORAGE (INCLUDING LOSSES)
C  BATMXOUT = MAX POWER (TW) TAKEN OUT OF BATTERY STORAGE (INCLUDING LOSSES)
C
          STORBCUR            = STORBCUR  - REMSTOR
          HBSTOR(IGMTH,IGMTD) = HBSTOR(IGMTH,IGMTD) - STORSUB
          HBSTLS(IGMTH,IGMTD) = HBSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
          BDISCH              = STORSUB / PERHRS(J)
          POWMXOUT            = MAX(POWMXOUT,BDISCH)
          BATMXOUT            = MAX(BATMXOUT,BDISCH)
         ENDIF
C
C ********************************************************************
C   OBTAIN ANY REMAINING INFLEXIBLE ELECTRIC LOAD FROM H2 FUEL CELLS
C ********************************************************************
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C FCCHARG   = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C TREMFSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM H2FC DURING SIM
C TDISCHHFC = TOTAL EN (TWH) AFTER LOSSES REMOVED FROM H2 STORAGE FOR GRID ELEC DURING SIM
C H2DCEFF   = FRACTION OF ENERGY IN H2 STORAGE FOR ELECTRICITY
C             NOT LOST DUE TO LOSSES GOING OUT OF STORAGE
C             SUCH LOSSES INCLUDE FUEL CELL LOSS (0.65 EFF),
C           = 0.5362: LATENT HEAT LOSS (0.846 EFF) & DC TO AC INVERTER LOSSES (0.975 EFF)
C             JACOBSON 2023 H2-NH3-STEEL PAPER
C HFSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) H2 FOR ELEC
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HFSTLS    = CUM ENERGY LOSS COMING OUT OF H2 FOR ELEC STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C STORFCUR  = CURRENT ENERGY AVAILABLE IN H2 STORAGE FOR GRID ELECTRICITY (TWH)
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C H2CURSTOR = CUR STORED NON-GRID H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2)
C H2CURMAX  = MAX TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2 DURING SIM
C EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C             IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C             CELL EFFIC, ETC.
C           = H2CHAREFF * H2DCEFF
C
         IF (STORTEM.GT.0.AND.IMERGH2.GE.1) THEN
C
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          IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
           STORSUB   = MIN(STORTEM,H2CURSTOR*EFFH2CD,FCDISCH*PERHRS(J))
           REMSTOR   = STORSUB   / EFFH2CD
           H2CURSTOR = H2CURSTOR - REMSTOR
          ELSE
           STORSUB   = MIN(STORTEM,STORFCUR*EFFH2CD,FCDISCH*PERHRS(J))
           REMSTOR   = STORSUB   / EFFH2CD
           STORFCUR  = STORFCUR  - REMSTOR
          ENDIF
C
          STORTEM   = STORTEM   - STORSUB
          TREMFSTOR = TREMFSTOR + STORSUB
          TDISCHHFC = TDISCHHFC + STORSUB
C
C REMFLEX = FLEXIBLE DEMAND (TWH) THAT CAN BE SATISFIED HERE BY BATTERY STORAGE
C EXCESIN = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C
          IF (STORSUB.GT.EXCESIN) THEN
           REMFLEX   = STORSUB   - EXCESIN
           REMAINDEM = REMAINDEM - REMFLEX
           ADDDEM    = ADDDEM    + REMFLEX
          ENDIF
C
          EXCESIN    = MAX(EXCESIN - STORSUB,0.)
C
C REDUCE AVAILABLE H2 STORAGE FOR ELECTRICITY
C  POWMXOUT = MAX POWER (TW) TAKEN OUT OF ALL ELEC STORAGE (INCLUDING LOSSES)
C  HFCMXOUT = MAX POWER (TW) TAKEN OUT OF GRID H2 STORAGE (INCLUDING LOSSES)
C
          HFSTOR(IGMTH,IGMTD) = HFSTOR(IGMTH,IGMTD) - STORSUB
          HFSTLS(IGMTH,IGMTD) = HFSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
          DISCHINST           = STORSUB / PERHRS(J)
          POWMXOUT            = MAX(POWMXOUT,DISCHINST)
          HFCMXOUT            = MAX(HFCMXOUT,DISCHINST)
         ENDIF
C        ENDIF STOREM>0 AND IMERGH2.GE.1
C
C ********************************************************************
C PROVIDE REMAINING FLEXIBLE+INFLEXIBLE LOAD FROM PUMPED-HYDRO STORAGE (PHS)
C ********************************************************************
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C STORPTWH  = MAX STORAGE CAPACITY (TWH) OF PHS STORAGE
C TSTORPHS  = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C TREMPSTOR = NET EN (TWH) (NOT LOSSES) REMOVED FROM PHS STORAGE DURING SIM
C STORPCUR  = CURRENT ENERGY AVAILABLE IN PHS STORAGE (TWH)
C PHSTLS    = CUM ENERGY LOSS COMING OUT OF PHS STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C PHSTLS    = CUM ENERGY LOSS COMING OUT OF PHS STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C
         IF (STORTEM.GT.0.) THEN
          STORSUB   = MIN(STORTEM,STORPCUR*RTPHSEFF,TSTORPHS*PERHRS(J))
          STORTEM   = STORTEM   - STORSUB
          REMSTOR   = STORSUB   / RTPHSEFF
          TREMPSTOR = TREMPSTOR + STORSUB
C
C REMFLEX = FLEXIBLE DEMAND (TWH) THAT CAN BE SATISFIED BY PHS STORAGE
C EXCESIN = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C ADDDEM  = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C           IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C           THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C
          IF (STORSUB.GT.EXCESIN) THEN
           REMFLEX   = STORSUB   - EXCESIN
           REMAINDEM = REMAINDEM - REMFLEX
           ADDDEM    = ADDDEM    + REMFLEX
          ENDIF
C
          EXCESIN    = MAX(EXCESIN - STORSUB,0.)
C
C REDUCE AVAILABLE PHS STORAGE
C
          STORPCUR            = STORPCUR - REMSTOR
          PHSTOR(IGMTH,IGMTD) = PHSTOR(IGMTH,IGMTD) - STORSUB
          PHSTLS(IGMTH,IGMTD) = PHSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
```

```
          POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
C
         ENDIF
C        ENDIF STORETEM>0
C
C ***********************************************************************
C                SATISFY  INFLEXIBLE LOAD NEXT FROM HYDRO
C ***********************************************************************
C THIS CALCULATION ASSUMES HYDROPOWER ENERGY IS CONSERVED (LIMITED
C BY TOTAL ENERGY AVAILABLE, HYDROTWH), AND THE DISCHARGE RATE IS LIMITED
C TO HYDISCHTW
C ***********************************************************************
C HYDROTWH  = CURRENT TWH OF AVAILABLE HYDROPOWER HELD IN RESERVOIRS IN REGION
C             FOR PEAKING POWER. MAX VALUE IS PKHYDMAX.  EACH TIME STEP, ADD
C             PEAKHYD*PERHRS TWH TO RESERVOIR. HYDRO SUBTRACTED AT RATE THAT VARIES
C             FROM 0 TO PKHYDISCH*PERHRS EACH TIME STEP. HYDROTWH DOES
C             NOT STORE HYDRO USED FOR BASELOAD. THAT IS STORED IN BASHYDMX
C             HYDROTWH INCLUDES ENERGY BEFORE T&D LOSSES ACCOUNTED FOR
C HYDISCHTW = MAX DISCHARGE RATE OF HYDROELECTRIC POWER (TW)
C PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
C           = HYDISCHTW - BASEHYD
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C HRSUPP    = CUM WIND+SOLAR+HYDRO+GEO+TIDAL+WAVE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C             THIS IS SUPPLY AFTER T&D LOSSES ARE TAKEN OUT
C HRHYDR    = CUM HYDRO PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             DIVIDE BY TDEFFMN(IHYDRO) AT END OT ACCOUNT FOR T&D LOSSES
C HRTDLS    = CUM WWS-ELECTRICITY TRANS&DIST LOSS OVER YEAR (TWH)
C           + SOLAR THERMAL DISTRIBUTION LOSS OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR.
C TWHHYD    = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHPKHYD  = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHBSHYD  = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHSUPPLY = TOTAL TWH OF ENERGY SUPPLIED BY WWS ELEC+HEAT DURING SIMULATION
C             AFTER T&D LOSSES ACCOUNTED FOR. THIS INCLUDES CURTAILED WIND/SOL
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C TDEFFMN   = 1-TDLOSMN = TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C
         IF (STORTEM.GT.0.AND.HYDROTWH.GT.0.) THEN
          STORSUB             = MIN(STORTEM,HYDROTWH*TDEFFMN(IHYDRO),
     1                            PKHYDISCH*PERHRS(J))
          STORTEM             = STORTEM  - STORSUB
          HYDROTWH            = HYDROTWH - STORSUB / TDEFFMN(IHYDRO)
C
C REMFLEX = FLEXIBLE DEMAND (TWH) THAT CAN BE SATISFIED HERE BY HYDRO STORAGE
C EXCESIN = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C
          IF (STORSUB.GT.EXCESIN) THEN
           REMFLEX   = STORSUB   - EXCESIN
           REMAINDEM = REMAINDEM - REMFLEX
           ADDDEM    = ADDDEM    + REMFLEX
          ENDIF
C
          EXCESIN    = MAX(EXCESIN - STORSUB,0.)
C
C TDRATMN = TDLOSMN / TDEFFMN. MULT ENERGY (TWH) DELIVERED AFTER T&D LOSSES
C           BY TDRATMN TO OBTAIN T&D ENERGY LOSS (TWH)
C
          HRSUPP(IGMTH,IGMTD) = HRSUPP(IGMTH,IGMTD) + STORSUB
          HRHYDR(IGMTH,IGMTD) = HRHYDR(IGMTH,IGMTD) + STORSUB
          HRTDLS(IGMTH,IGMTD) = HRTDLS(IGMTH,IGMTD) + STORSUB
     1                          * TDRATMN(IHYDRO)
          TWHHYD              = TWHHYD              + STORSUB
          TWHPKHYD            = TWHPKHYD            + STORSUB
          TWHSUPPLY           = TWHSUPPLY           + STORSUB
          POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
         ENDIF
C        ENDIF STORTEM>0
C
C ***********************************************************************
C CHECK IF TOO MUCH ENERGY IS DRAWN FROM STORAGE OR NOT ENOUGH AVAILABLE
C ***********************************************************************
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C EXCESIN   = INFLEXIBLE CURRENT DEMAND (TWH) IN EXCESS OF CURRENT SUPPLY
C PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
```

```
C           = HYDISCHTW - BASEHYD
C
         IF (EXCESIN.GT.1.0E-12) THEN
          WRITE(IOUT,208)
          WRITE(IOUT,285) TIMWWS(J)/HRSPDAY, STORTEM,EXCESIN,STORSUB,
     1       SUPPLY(J), SUPPHT(J), WARMTWH, COLDTWH,FLEXLOAD,FLEXH2LD,
     1       DEMANDNEW, DEMINFLEX, DEMAND(J), REMAINDEM,
     1       STORCCUR,  STORPCUR, STORBCUR,STORFCUR,STOROCUR,STORHCUR,
     1       UGSTORCUR, HYDROTWH, H2CURSTOR, BRSTORCUR, REMSTOR,
     1       CSPDIFF*PERHRS(J),
     1       TSTORPHS*PERHRS(J),HYDISCHTW*PERHRS(J),PKHYDISCH*PERHRS(J),
     1       BATDISCH*PERHRS(J),FCDISCH *PERHRS(J),PERHRS(J)
 285      FORMAT(/'POWERWORLD3: REMAINING INFLEX LOAD (EXCESIN)>0',/
     1           'TIME(DAYS)            ',0PF14.8,/
     1           'STORTEM(TWH)          ',0PF14.8,/
     1           'EXCESIN(TWH)          ',0PF14.8,/
     1           'STORSUB(TWH)          ',0PF14.8,/
     1           'SUPPLY(TWH)           ',0PF14.8,/
     1           'SUPPHT(TWH)           ',0PF14.8,/
     1           'WARMTWH(TWH)          ',0PF14.8,/
     1           'COLDTWH(TWH)          ',0PF14.8,/
     1           'FLEXLOAD(TWH)         ',0PF14.8,/
     1           'FLEXH2LD(TWH)         ',0PF14.8,/
     1           'DEMANDNEW(TWH)        ',0PF14.8,/
     1           'DEMINFLEX(TWH)        ',0PF14.8,/
     1           'DEMAND(TWH)           ',0PF14.8,/
     1           'REMAINDEM(TWH)        ',0PF14.8,/
     1           'STORCCUR(TWH)         ',0PF14.8,/
     1           'STORPCUR(TWH)         ',0PF14.8,/
     1           'STORBCUR(TWH)         ',0PF14.8,/
     1           'STORFCUR(TWH)         ',0PF14.8,/
     1           'STOROCUR(TWH)         ',0PF14.8,/
     1           'STORHCUR(TWH)         ',0PF14.8,/
     1           'UGSTORCUR(TWH)        ',0PF14.8,/
     1           'HYDROTWH(TWH)         ',0PF14.8,/
     1           'H2CURSTOR(TWH)        ',0PF14.8,/
     1           'BRSTORCUR(TWH)        ',0PF14.8,/
     1           'REMSTOR(TWH)          ',0PF14.8,/
     1           'CSPDIFF  *PERHRS(TWH) ',0PF14.8,/
     1           'TSTORPHS *PERHRS(TWH) ',0PF14.8,/
     1           'HYDISCHTW*PERHRS(TWH) ',0PF14.8,/
     1           'PKHYDISCH*PERHRS(TWH) ',0PF14.8,/
     1           'BATDISCH *PERHRS(TWH) ',0PF14.8,/
     1           'FCDISCH  *PERHRS(TWH) ',0PF14.8,/
     1           'PERHRS(HRS)           ',0PF14.8,/)

          STOP
         ENDIF
C
C ***************************************************************************
C HIGHER FLEXIBLE+INFLEXIBLE DEMAND THAN SUPPLY, SUPPLY FLEXIBLE LOAD UP
C TO LIMIT WITH CURRENT SUPPLY THEN SUPPLY AS MUCH OF REMAINING FLEXIBLE LOAD
C FROM STORAGE, THEN PUSH REMAINING FLEXIBLE LOAD BEYOND SUPPLY + STORAGE
C TO NEXT HOUR
C ***************************************************************************
C ADDDEM   = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C            IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C            THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C
        ELSEIF (DEMANDNEW.GT.SUPPLY(J)) THEN
C
C REDUCE FLEXIBLE DEMAND TO EXTENT IT WAS SUPPLIED FROM CURRENT SUPPLY
C
         ADDDEM    = MIN(SUPPLY(J) - DEMINFLEX,REMAINDEM)
         REMAINDEM = REMAINDEM - ADDDEM
C
C ***************************************************************************
C SUPPLY AS MUCH OF REMAINING FLEXIBLE LOAD FROM STORAGE AS POSSIBLE
C ***************************************************************************
C
         IF (REMAINDEM.GT.0.) THEN
C
C ***************************************************************************
C           FLEXIBLE + INFLEXIBLE LOAD FIRST FROM CSP STORAGE
C ***************************************************************************
```

```
C STORSUB   = TWH SUBTRACTED FROM STORAGE AFTER EFFIC LOSS ACCOUNTED FOR
C STORCCUR  = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C REMSTOR   = CUR TOTAL ENERGY (TWH) REMOVED FROM STORAGE. THIS IS ENERGY
C             USED PLUS ENERGY LOST DUE TO EFFICIENCY LOSS COMING OUT OF STORAGE
C TREMCSTOR = NET EN (TWH) (NOT LOSSES) REM FROM CSP STORAGE DURING SIM
C CSPDIFF   = DIFFERENCE (TW) BETWEEN MAX CSP DISCHARGE RATE AND CSP
C             PRODUCED DURING CURRENT TIME STEP ALREADY DISCHARGED DIRECTLY
C             (NOT THRU STORAGE) DURING CURRENT TIME STEP.
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C           = CSPCHARG - CSPCHSTO = CSP TURBINE SIZE
C             IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C CURCSP    = CURRENT SOLAR POWER (TW) EXTRACTED FROM CSP AFTER T&D LOSSES
C             AFTER CSP BEYOND CUR CSP DISCHARGE RATE (EXTRACSP) PUT IN STORAGE
C ADDDEM    = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C             IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C             THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C HCSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CSP STORAGE
C             EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN AND OUT OF STORAGE
C HCSTLS    = CUM ENERGY LOSS COMING OUT OF CSP STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C RTCSPEFF  = SQRT(EFFCSP)
C           = FRACTION OF ENERGY ADDED TO OR REMOVED FROM PHASE-CHANGE MATERIAL
C             IN CSP THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C
          CSPDIFF   = MAX(CSPDISCH - CURCSP(J),0.)
          STORSUB   = MIN(REMAINDEM,STORCCUR*RTCSPEFF,CSPDIFF*PERHRS(J))
          REMAINDEM = REMAINDEM - STORSUB
          ADDDEM    = ADDDEM    + STORSUB
          REMSTOR   = STORSUB   / RTCSPEFF
          TREMCSTOR = TREMCSTOR + STORSUB
C
C REDUCE AVAILABLE STORAGE
C
          STORCCUR            = STORCCUR - REMSTOR
          HCSTOR(IGMTH,IGMTD) = HCSTOR(IGMTH,IGMTD) - STORSUB
          HCSTLS(IGMTH,IGMTD) = HCSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
          POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
C
C ***********************************************************************
C    ANY REMAINING FLEX+INFLEXIBLE ELECTRICAL LOAD FROM BATTERIES
C ***********************************************************************
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C STORBCUR  = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C TREMBSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM BATTERIES DURING SIM
C TDISCHBAT = TOTAL EN (TWH) (INCLUDING LOSSES) REMOVED FROM BAT DURING SIM
C RTBATEFF  = SQRT(EFFBAT)
C           = FRACTION OF ENERGY IN BATTERY STORAGE
C             THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C             APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HBSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) BATTERY
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HBSTLS    = CUM ENERGY LOSS COMING OUT OF BATTERY STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C
          IF (REMAINDEM.GT.0.) THEN
           STORSUB = MIN(REMAINDEM,STORBCUR*RTBATEFF,BATDISCH*PERHRS(J))
           REMAINDEM = REMAINDEM - STORSUB
           ADDDEM    = ADDDEM    + STORSUB
           REMSTOR   = STORSUB   / RTBATEFF
           TREMBSTOR = TREMBSTOR + STORSUB
           TDISCHBAT = TDISCHBAT + REMSTOR
C
C REDUCE AVAILABLE STORAGE
C  POWMXOUT = MAX POWER (TW) TAKEN OUT OF ALL ELEC STORAGE (INCLUDING LOSSES)
C  BATMXOUT = MAX POWER (TW) TAKEN OUT OF BATTERY STORAGE (INCLUDING LOSSES)
C
           STORBCUR            = STORBCUR - REMSTOR
           HBSTOR(IGMTH,IGMTD) = HBSTOR(IGMTH,IGMTD) - STORSUB
           HBSTLS(IGMTH,IGMTD) = HBSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
           BDISCH              = STORSUB / PERHRS(J)
           POWMXOUT            = MAX(POWMXOUT,BDISCH)
           BATMXOUT            = MAX(BATMXOUT,BDISCH)
```

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          ENDIF
C
C *********************************************************************
C    ANY REMAINING FLEX+INFLEXIBLE ELECTRICAL LOAD FROM H2 FUEL CELLS
C *********************************************************************
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C TREMFSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM H2FC DURING SIM
C TDISCHHFC = TOTAL EN (TWH) AFTER LOSSES REMOVED FROM H2 STORAGE FOR GRID ELEC DURING SIM
C H2DCEFF   = FRACTION OF ENERGY IN H2 STORAGE FOR ELECTRICITY
C             NOT LOST DUE TO LOSSES GOING OUT OF STORAGE
C             SUCH LOSSES INCLUDE FUEL CELL LOSS (0.65 EFF),
C           = 0.5362: LATENT HEAT LOSS (0.846 EFF) & DC TO AC INVERTER LOSSES (0.975 EFF)
C             JACOBSON 2023 H2-NH3-STEEL PAPER
C HFSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) H2 FOR ELEC
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HFSTLS    = CUM ENERGY LOSS COMING OUT OF H2 FOR ELEC STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C STORFCUR  = CURRENT ENERGY AVAILABLE IN H2 STORAGE FOR GRID ELECTRICITY (TWH)
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C H2CURSTOR = CUR STORED NON-GRID H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2)
C H2CURMAX  = MAX TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2 DURING SIM
C EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C             IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C             CELL EFFIC, ETC.
C           = H2CHAREFF * H2DCEFF
C             MULTIPLY BY H2CHAREFF BECAUSE THE KWH IN STORAGE INCLUDES
C             THE KWH OF WASTED ENERGY TO PRODUCE THE H2, SO WHEN
C             ELECTRICITY IS PRODUCED, CAN'T USE THAT WASTE
C             NOTE THAT THE TANK IS ACTUALLY STORING KG-H2, BUT
C             ELECTRICITY UNITS ARE USED FOR SIMPLICITY.
C
          IF (REMAINDEM.GT.0.AND.IMERGH2.GE.1) THEN
C
           IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
            STORSUB  =MIN(REMAINDEM,H2CURSTOR*EFFH2CD,FCDISCH*PERHRS(J))
            REMSTOR   = STORSUB   / EFFH2CD
            H2CURSTOR = H2CURSTOR - REMSTOR
           ELSE
            STORSUB  = MIN(REMAINDEM,STORFCUR*EFFH2CD,FCDISCH*PERHRS(J))
            REMSTOR  = STORSUB   / EFFH2CD
            STORFCUR = STORFCUR  - REMSTOR
           ENDIF
C
           REMAINDEM = REMAINDEM - STORSUB
           ADDDEM    = ADDDEM    + STORSUB
           TREMFSTOR = TREMFSTOR + STORSUB
           TDISCHHFC = TDISCHHFC + STORSUB
C
C REDUCE AVAILABLE STORAGE
C  POWMXOUT = MAX POWER (TW) TAKEN OUT OF ALL ELEC STORAGE (INCLUDING LOSSES)
C  HFCMXOUT = MAX POWER (TW) TAKEN OUT OF GRID H2 STORAGE (INCLUDING LOSSES)
C
           HFSTOR(IGMTH,IGMTD) = HFSTOR(IGMTH,IGMTD) - STORSUB
           HFSTLS(IGMTH,IGMTD) = HFSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
           DISCHINST           = STORSUB / PERHRS(J)
           POWMXOUT            = MAX(POWMXOUT,DISCHINST)
           HFCMXOUT            = MAX(HFCMXOUT,DISCHINST)
          ENDIF
C         ENDIF REMAINDEM>0 AND IMERGH2.GE.1
C
C *********************************************************************
C PROVIDE REMAINING FLEXIBLE+INFLEXIBLE LOAD FROM PUMPED-HYDRO STORAGE (PHS)
C *********************************************************************
C STORPTWH = MAX STORAGE CAPACITY (TWH) OF PHS STORAGE
C TSTORPHS = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C STORPCUR = CURRENT ENERGY AVAILABLE IN PHS STORAGE (TWH)
C PHSTLS   = CUM ENERGY LOSS COMING OUT OF PHS STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C PHSTLS   = CUM ENERGY LOSS COMING OUT OF PHS STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C
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          IF (REMAINDEM.GT.0.) THEN
           STORSUB = MIN(REMAINDEM,STORPCUR*RTPHSEFF,TSTORPHS*PERHRS(J))
           REMAINDEM = REMAINDEM - STORSUB
           ADDDEM    = ADDDEM    + STORSUB
           REMSTOR   = STORSUB   / RTPHSEFF
           TREMPSTOR = TREMPSTOR + STORSUB
C
C REDUCE AVAILABLE STORAGE
C
           STORPCUR            = STORPCUR - REMSTOR
           PHSTOR(IGMTH,IGMTD) = PHSTOR(IGMTH,IGMTD) - STORSUB
           PHSTLS(IGMTH,IGMTD) = PHSTLS(IGMTH,IGMTD) + REMSTOR - STORSUB
           POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
          ENDIF
C
C *********************************************************************
C  REMAINING FLEX+INFLEXIBLE ELECTRICAL LOAD FROM CONVENTIONAL HYDRO
C                 WHEN IT IS ABOVE THRESHHOLD
C *********************************************************************
C THIS CALCULATION ASSUMES HYDROPOWER ENERGY IS CONSERVED (LIMITED
C BY TOTAL ENERGY AVAILABLE, HYDROTWH), AND THE DISCHARGE RATE IS LIMITED
C BY PKHYDISCH
C *********************************************************************
C ADDDEM    = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C             IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C             THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C HRTDLS    = CUM WWS-ELECTRICITY TRANS&DIST LOSS OVER YEAR (TWH)
C           + SOLAR THERMAL DISTRIBUTION LOSS OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR.
C HYDROTWH  = CURRENT TWH OF AVAILABLE HYDROPOWER HELD IN RESERVOIRS IN REGION
C             FOR PEAKING POWER. MAX VALUE IS PKHYDMAX.  EACH TIME STEP, ADD
C             PEAKHYD*PERHRS TWH TO RESERVOIR. HYDRO SUBTRACTED AT RATE THAT VARIES
C             FROM 0 TO PKHYDISCH*PERHRS EACH TIME STEP. HYDROTWH DOES
C             NOT STORE HYDRO USED FOR BASELOAD. THAT IS STORED IN BASHYDMX
C             HYDROTWH INCLUDES ENERGY BEFORE T&D LOSSES ACCOUNTED FOR
C HRHYDR    = CUM HYDRO PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             DIVIDE BY TDEFFMN(IHYDRO) AT END OT ACCOUNT FOR T&D LOSSES
C PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
C           = HYDISCHTW - BASEHYD
C TWHHYD    = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHPKHYD  = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHBSHYD  = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C
          IF (REMAINDEM.GT.0.AND.HYDROTWH.GT.0.) THEN
           STORSUB             = MIN(REMAINDEM,HYDROTWH*TDEFFMN(IHYDRO),
     1                             PKHYDISCH*PERHRS(J))
           REMAINDEM           = REMAINDEM - STORSUB
           HYDROTWH            = HYDROTWH  - STORSUB / TDEFFMN(IHYDRO)
           ADDDEM              = ADDDEM    + STORSUB
C
           HRSUPP(IGMTH,IGMTD) = HRSUPP(IGMTH,IGMTD) + STORSUB
           HRHYDR(IGMTH,IGMTD) = HRHYDR(IGMTH,IGMTD) + STORSUB
           HRTDLS(IGMTH,IGMTD) = HRTDLS(IGMTH,IGMTD) + STORSUB
     1                         * TDRATMN(IHYDRO)
           TWHHYD              = TWHHYD              + STORSUB
           TWHPKHYD            = TWHPKHYD            + STORSUB
           TWHSUPPLY           = TWHSUPPLY           + STORSUB
           POWMXOUT            = MAX(POWMXOUT,STORSUB/PERHRS(J))
          ENDIF
C         ENDIF REMAINDEM.GT.0.AND.HYDROTWH>0.
C
         ENDIF
C        ENDIF REMAINDEM>0
C
C *********************************************************************
C HIGHER SUPPLY THAN INFLEXIBLE DEMAND, THEN SUPPLY FLEXIBLE DEMAND AND
C                     ADD REMAINDER TO STORAGE
C *********************************************************************
C ADDDEM   = FLEXIBLE DEMAND (TWH) THAT IS SATISFIED BY EITHER CURRENT SUPPLY
C            IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C            THIS WILL BE ADDED TO HRFLXLD AND TWHDEMAND LATER
C
        ELSEIF (SUPPLY(J).GT.DEMANDNEW) THEN
         ADDDEM    = REMAINDEM
         REMAINDEM = 0.
```

```
C
C IF SUPPLY > FLEXIBLE + INFLEXIBLE DEMAND --> ADD DIFF TO NON-UTES STORAGE
C
C ***********************************************************************
C               ADD EXCESS SUPPLY FIRST TO CSP STORAGE
C      ONLY CURRENT CSP PRODUCTION (CURCSP) PUT INTO CSP STORAGE
C ***********************************************************************
C STORADD  = NET ENERGY (TWH) ADDED TO STORAGE DURING INTERVAL PERHRS
C            (NET ENERGY IS ENERGY AFTER EFFICIENCY LOSS ACCOUNTED FOR)
C EFFLOS   = ENERGY LOST (TWH) DURING TRANSFER OF ENERGY TO STORAGE
C CSPCHARG = MAX CHARGE RATE (TW) OF CSP DIRECT ELECTRICITY + STORAGE
C          = CSPDISCH + CSPCHSTO
C            IF NO STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C            BASED ON SIZE OF MIRRORS (NOT SIZE OF GENERATOR)
C CURCSP   = CURRENT SOLAR POWER (TW) EXTRACTED FROM CSP AFTER T&D LOSSES
C            AFTER CSP BEYOND CUR CSP DISCHARGE RATE (EXTRACSP) PUT IN STORAGE
C CSPCHSTO = MAX CHARGE RATE (TW) OF CSP STORAGE ONLY (NOT STORAGE +
C            DIRECT ELECTRICITY FROM TURBINES)  WHEN STORAGE EXISTS.
C          = CSPCHARG - CSPDISCH
C            IF NO CSP STORAGE -> CSPCHARG = CSPDISCH AND CSPCHSTO = 0
C STORCTWH = MAX NUMBER OF TWH OF CSP STORAGE
C RTCSPEFF = SQRT(EFFCSP)
C          = FRACTION OF ENERGY ADDED TO OR REMOVED FROM PHASE-CHANGE MATERIAL
C            IN CSP THAT IS NOT LOST DUE TO T&D LOSSES
C            APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HCSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CSP STORAGE
C            EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C            IN AND OUT OF STORAGE
C HCSTLS   = CUM ENERGY LOSS COMING OUT OF CSP STORAGE OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C HCSTLI   = CUM ENERGY LOSS GOING INTO CSP STORAGE ONLY OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C          = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C            STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C EXCESS   = EXCESS ELECTRICITY SUPPLY (TWH) OVER INFLEX+FLEX DEMAND (TWH)
C DEMANDNEW= TOTAL INFLEXIBLE+FLEXIBLE LOAD (TWH) FOR CURRENT TIME INCREMENT
C
        EXCESS              = SUPPLY(J) - DEMANDNEW
C
C INCLUDING CURCSP IN THIS STATEMENT ENSURES ONLY CSP ENERGY ADDED TO STORAGE
C
        STORADD             = MIN(EXCESS               * RTCSPEFF,
     1                            CURCSP(J) * PERHRS(J) * RTCSPEFF,
     1                            CSPCHSTO  * PERHRS(J) * RTCSPEFF,
     1                            STORCTWH  - STORCCUR)
        STORCCUR            = STORCCUR + STORADD
        EFFLOS              = STORADD  / RTCSPEFF - STORADD
        HCSTOR(IGMTH,IGMTD) = HCSTOR(IGMTH,IGMTD) + STORADD
        HCSTLI(IGMTH,IGMTD) = HCSTLI(IGMTH,IGMTD) + EFFLOS
        EXCESS              = MAX(EXCESS-STORADD-EFFLOS,0.)
        POWMXIN             = MAX(POWMXIN,STORADD/PERHRS(J))
C
C ***********************************************************************
C           ADD EXCESS SUPPLY NEXT TO BATTERY STORAGE
C ***********************************************************************
C BATDISCH = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C STORBTWH = MAX STORAGE CAPACITY (TWH) OF BATTERY STORAGE
C STORBCUR = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C RTBATEFF = SQRT(EFFBAT)
C          = FRACTION OF ENERGY IN BATTERY STORAGE
C            THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C            APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HBSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) BATTERY
C            STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C            COMING IN AND OUT OF STORAGE
C HBSTLS   = CUM ENERGY LOSS COMING OUT OF BATTERY STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C HBSTLI   = CUM ENERGY LOSS GOING INTO BATTERY STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C          = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C            STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C
        STORADD             = MIN(EXCESS * RTBATEFF,
     1                            BATDISCH  * PERHRS(J) * RTBATEFF,
     1                            STORBTWH  - STORBCUR)
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```
         STORBCUR            = STORBCUR + STORADD
         EFFLOS              = STORADD / RTBATEFF - STORADD
         HBSTOR(IGMTH,IGMTD) = HBSTOR(IGMTH,IGMTD) + STORADD
         HBSTLI(IGMTH,IGMTD) = HBSTLI(IGMTH,IGMTD) + EFFLOS
         EXCESS              = MAX(EXCESS-STORADD-EFFLOS,0.)
         POWMXIN             = MAX(POWMXIN,STORADD/PERHRS(J))
C
C ***********************************************************************
C ADD EXCESS SUPPLY NEXT TO H2 STORAGE USED FOR FUEL CELLS FOR GRID ELEC
C ***********************************************************************
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C FCCHARG   = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C TREMFSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM H2FC DURING SIM
C TDISCHHFC = TOTAL EN (TWH) AFTER LOSSES REMOVED FROM H2 STORAGE FOR GRID ELEC DURING SIM
C H2CHAREFF = FRACTION OF ENERGY IN H2FC STORAGE
C             NOT LOST DUE TO T&D LOSSES AND LOSSES CHARGING H2 STORAGE
C           = 0.8338: INCLUDES ELECTROLYZER LOSS (0.95 EFF), COMPRESSOR LOSS
C             (0.8803 EFF) AND LEAKS (0.997 EFF) - JACOBSON 2023 H2-NH3-STEEL PAPER
C HFSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) H2 FOR ELEC
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HFSTLS    = CUM ENERGY LOSS COMING OUT OF H2 FOR ELEC STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C STORTEM   = EXCESS INFLEXIBLE+FLEXIBLE DEMAND OVER SUPPLY (TWH)
C STORFCUR  = CURRENT ENERGY AVAILABLE IN H2 STORAGE FOR GRID ELECTRICITY (TWH)
C STORH2MX  = MAX TWH OF GRID H2 STORED ANYTIME DURING SIMULATION
C STORFTWH  = MAX STORAGE CAPACITY (TWH) OF ENERGY TO MAKE H2 FOR GRID ELEC STORAGE
C           = ENERGY IN ELECTRICITY USED TO PRODUCE/COMPRESS HYDROGEN
C             MULT STORFTWH BY H2CHAREFF TO GET MAX ENERGY IN H2 IN STORAGE
C           = MAX H2 IN STORAGE (TG-H2) * H2ENERGY (KWH/KG-H2)
C           = MAX ENERGY FROM FUEL CELL (TWH) / (H2DCEFF*H2CHAREFF)
C           = FCDISCH (TW) * STORHHFC (HOURS) / (H2DCEFF*H2CHAREFF)
C           = H2SDISCH TW) * STORHHFC(HOURS)
C           = 0 WHEN IMERGH2 = 1,3 OR 0
C H2TCUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR NON-GRID STORAGE WHEN IMERGH2=0 OR NON-GRID + GRID STORAGE
C             WHEN IMERGH2=1,3
C H2ECUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR GRID ELECTRICITY STORAGE WHEN IMERGH2=2
C STORADD   = CURRENT ELECTRICITY (TWH) USED TO PRODUCE & COMPRESS H2
C             GRID ELECTRICITY STORAGE.
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C H2CURSTOR = CUR STORED NON-GRID H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2)
C H2CURMAX  = MAX TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2 DURING SIM
C H2PEAKLD  = LARGEST INSTANT NON-GRID H2 PRODUCTION LOAD (TW) ALLOWED
C             VIA ELECTROLYZERS/COMPRESSORS FOR NON-GRID H2 WHEN IMERGH2=0 OR
C             2 AND GRID PLUS NON-GRID H2 WHEN IMERGH2=1,3
C             ENSURE H2PEAKLD IS AT LEAST AS BIG AS FCCHARG WHEN IMERGH2=1,3
C IMERGH2   = 0: DO NOT INCLUDE ANY H2 FOR GRID ELECTRICITY
C           = 1: MERGE ELECTROLYZERS, COMPRESSORS, & STORAGE FOR
C                GRID AND NON-GRID H2.
C           = 2: KEEP ELECTROLYZERS, COMPRESSORS, & STORAGE
C                SEPARATE FOR GRID VERSUS NON-GRID H2
C           = 3: SAME AS IMERGH2=1, BUT BATDISCH=0 (NO BATTERIES)
C
C ONLY ADD ELECTRICITY TO H2 STORAGE FOR GRID ELECTRICITY IF FCCHARG>0
C       H2PEAKLD IS AT LEAST AS BIG AS FCCHARG WHEN IMERGH2=1,3
C
         IF (FCCHARG.GT.0.) THEN
          IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
           STORADD              = MIN(EXCESS,MAX(H2STORMX-H2CURSTOR,0.),
     1                                H2PEAKLD*PERHRS(J))
           H2CURSTOR            = H2CURSTOR            + STORADD
           H2STOR( IGMTH,IGMTD) = H2STOR( IGMTH,IGMTD) + STORADD
           EXCESS               = MAX(EXCESS - STORADD,0.)
           H2CURMAX             = MAX(H2CURSTOR,H2CURMAX)
           H2LDPEAKI            = MAX(H2LDPEAKI,STORADD/PERHRS(J))
           H2TCUMTWH            = H2TCUMTWH            + STORADD
          ELSEIF (IMERGH2.EQ.2) THEN
           STORADD              = MIN(EXCESS,MAX(STORFTWH-STORFCUR,0.),
     1                                FCCHARG  * PERHRS(J))
           STORFCUR             = STORFCUR             + STORADD
           HFSTOR(IGMTH,IGMTD)  = HFSTOR(IGMTH,IGMTD)  + STORADD
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           EXCESS               = MAX(EXCESS - STORADD,0.)
           STORH2MX             = MAX(STORH2MX,STORFCUR)
           POWMXIN              = MAX(POWMXIN,STORADD/PERHRS(J))
           H2ECUMTWH            = H2ECUMTWH + STORADD
          ENDIF
         ENDIF
C
C ***********************************************************************
C                ADD EXCESS SUPPLY NEXT TO PHS STORAGE
C ***********************************************************************
C STORPTWH = MAX STORAGE CAPACITY (TWH) OF PHS STORAGE
C TSTORPHS = MAX DISCHARGE AND CHARGE RATE (TW) OF PHS
C STORPCUR = CURRENT ENERGY AVAILABLE IN PHS STORAGE (TWH)
C PHSTLS   = CUM ENERGY LOSS COMING OUT OF PHS STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C PHSTLI   = CUM ENERGY LOSS GOING INTO PHS STORAGE ONLY OVER
C            YEAR (TWH) FOR EACH 1..24 GMT HR
C
         STORADD              = MIN(EXCESS * RTPHSEFF,
     1                             TSTORPHS * PERHRS(J) * RTPHSEFF,
     1                             STORPTWH - STORPCUR)
         STORPCUR             = STORPCUR + STORADD
         EFFLOS               = STORADD / RTPHSEFF - STORADD
         PHSTOR(IGMTH,IGMTD) = PHSTOR(IGMTH,IGMTD) + STORADD
         PHSTLI(IGMTH,IGMTD) = PHSTLI(IGMTH,IGMTD) + EFFLOS
         EXCESS               = MAX(EXCESS-STORADD-EFFLOS,0.)
         POWMXIN              = MAX(POWMXIN,STORADD/PERHRS(J))
C
C ***********************************************************************
C       ADD EXCESS SUPPLY NEXT TO BRICK INDUSTRIAL HEAT STORAGE
C ***********************************************************************
C BRSTORCUR = CURRENT ENERGY IN BRICK IND HEAT STORAGE (TWH)
C STOHBTWH  = MAX STORAGE CAPACITY (TWH-THERMAL) OF BRICK HEAT BATTERY STORAGE
C RTHBTEFF  = SQRT(EFFHTBAT)
C           = FRACTION OF ENERGY IN HEAT BATTERY STORAGE
C             THAT IS NOT LOST, DUE TO LOSSES FROM CHARGING & DISCHARGING
C             APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C HBTDISCH  = MAX DISCHARGE RATE (TW-TH) OF FIREBRICK BATTERIES
C HBTCHARG  = MAX CHARGE RATE (TW-AC) OF FIREBRICK BATTERIES
C           = 3.5 X MAX DISCHARGE RATE FOR RHB300 FOR RONDO DATASHEET
C             MAX CHARGE RATE IS 70 MW-AC; MAX DISCH RATE IS 20 MW-TH
C BRSTOR    = CUM USABLE NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HI-T BRICK
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN & OUT OF STORAGE OR LOST FROM STORAGE DUE TO CONDUCTION
C BRSTLI    = CUM ENERGY LOSS COMING INTO BRICK STORAGE ONLY OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C           = SAME AS BRSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C
         STORADD              = MIN(EXCESS   * RTHBTEFF,
     1                             HBTCHARG * PERHRS(J) * RTHBTEFF,
     1                             STOHBTWH  - BRSTORCUR)
         BRSTORCUR            = BRSTORCUR + STORADD
         EFFLOS               = STORADD / RTHBTEFF - STORADD
         BRSTOR(IGMTH,IGMTD) = BRSTOR(IGMTH,IGMTD) + STORADD
         BRSTLI(IGMTH,IGMTD) = BRSTLI(IGMTH,IGMTD) + EFFLOS
         EXCESS               = MAX(EXCESS-STORADD-EFFLOS,0.)
C
C ***********************************************************************
C       ADD EXCESS SUPPLY NEXT TO  CW-STES + PCM-ICE STORAGE
C ***********************************************************************
C TSTORCOOL = AVG ANNUAL LOAD (TW) FOR COOLING (AC & REFRIG) SUBJECT TO STORAGE
C           = MAX DISCHARGE AND CHARGE RATE (TW) FOR CW-STES + PCM-ICE STORAGE
C STOROTWH  = MAX STORAGE CAPACITY (TWH) OF CW-STES + PCM-ICE STORAGE
C STOROCUR  = CURRENT ENERGY AVAILABLE IN CW-STES + PCM-ICE STORAGE (TWH)
C RTCOLDEF  = SQRT(EFFCOLD)
C           = FRACTION OF ENERGY IN CW-STES + PCM-ICE STORAGE
C             THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTCSPEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C HOSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CW-STES + PCM-ICE
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HOSTLS    = CUM ENERGY LOSS COMING OUT OF CW-STES+PCM-ICE STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C HOSTLI    = CUM ENERGY LOSS GOING INTO CW-STES + PCM-ICE STORAGE ONLY OVER
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C             YEAR (TWH) FOR EACH 1..24 GMT HR
C           = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C
         STORADD             = MIN(EXCESS    * RTCOLDEF,
     1                             TSTORCOOL * PERHRS(J) * RTCOLDEF,
     1                             STOROTWH  - STOROCUR)
         STOROCUR            = STOROCUR + STORADD
         EFFLOS              = STORADD / RTCOLDEF - STORADD
         HOSTOR(IGMTH,IGMTD) = HOSTOR(IGMTH,IGMTD) + STORADD
         HOSTLI(IGMTH,IGMTD) = HOSTLI(IGMTH,IGMTD) + EFFLOS
         EXCESS              = MAX(EXCESS-STORADD-EFFLOS,0.)
C
C ***********************************************************************
C IF STILL EXCESS ELECTRICITY AVAILABLE, ADD TO HW-STES STORAGE THEN
C UNDERGROUND HEAT STORAGE IN SOIL OR WATER (UTES) THEN USE TO PRODUCE H2 THEN CURTAIL
C ***********************************************************************
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C UTESCHARG = MAX CHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             FROM EXCESS ELECTRIC POWER GENERATION
C             SINCE LOW-TEMP HEAT LOAD IN countrystats.dat ALREADY
C             CONVERTED TO EQUIVALENT ELECTRICAL LOAD ASSUMING
C             HEAT PUMPS WITH CPERFORM, UTESCCHARG IS REALLY THE CHARGE
C             RATE OF EQUIV ELECTRICITY TO GIVE HEATING FROM HEAT PUMPS
C UTESTWH   = TWH OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL OR WATER
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C STORUGHRS = HOURS OF UNDERGROUND SEASONAL HEAT STORAGE IN SOIL OR WATER (UTES) (HRS)
C UGSTORCUR = CURRENT ENERGY IN UNDERGROUND SOIL OR WATER STORAGE (TWH)
C             REALLY CURRENT TWH OF ELECTRICITY STORED IN UTES THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UGSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) UTES STORAGE
C             EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN AND OUT OF UTES STORAGE
C             REALLY TWH OF ELECTRICITY STORAGE ADDED THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C UGSTLS    = CUM ENERGY LOSS GOING OUT OF UTES STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C UGSTLI    = CUM ENERGY LOSS COMING INTO UTES STORAGE ONLY OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C           = SAME AS UGSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C EXCESS    = EXCESS ENERGY (TWH) AVAILABLE TO BE USED FOR H2 OR
C             ADDED TO UNDERGROUND STORAGE
C RTUGEFF   = SQRT(EFFUTES)
C           = FRACTION OF ENERGY IN HEATED FLUID ADDED TO/REMOVED
C             FROM UNDERGROUND STORAGE THAT IS NOT LOST DUE TO T&D LOSSES
C             APPLY RTUGEFF SEPARATELY DURING CHARGING AND DISCHARGING.
C             RTUGEFF^2=EFFUTES = OVERALL EFFIC OF HEATING SOIL OR WATER WITH HEATED
C             FLUID THEN RETURNING HEAT TO FLUID IN OPPOSITE SEASON AND
C             USING THE HEATED FLUID TO HEAT AIR OR WATER.
C             EFFUTES IS EFFICIENCY AFTER EITHER FLUID HAS ALREADY BEEN HEATED
C             FROM ELECTRICITY OR SUN
C ENSHED    = TWH OF ENERGY CURTAILED WHEN TOO MUCH ELECTRICITY GENERATION
C             PUT INTO H2 PRODUCTION/COMPRESSION/STORAGE
C H2CURSTOR = CUR STORED H2 (TWH-ELECTRICITY USED TO PRODUCE/COMPRESS/STORE H2)
C H2STOR    = CUM NET TWH ENERGY ADDED TO PRODUCING/COMPRESSING/STORING (+)
C             SUBTRAC FROM USING (-) H2 EACH 1..24 GMT HR. INCL EN FOR LEAKED H2
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C           = TOTAL TWH OF H2 THAT CAN BE PUT IN STORAGE. DAYH2STOR CHANGES VALUE.
C
C ***********************************************************************
C  STORE EXCESS ELECTRICITY NEXT IN HOT WATER TANKS/BOILERS (HW-STES)
C ***********************************************************************
C HWADD    = TWH ADDED TO HW-STES STORAGE
C HWLOSS   = TWH LOST DURING CHARGING OF HW-STES STORAGE
C HOTCHARG = MAX CHARGE RATE (TW) OF HOT WATER (HW)-STES
C            REALLY MAX CHARGE RATE OF ELECTRICITY TO
C            PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C            THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C            countrystats.dat
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C RTHTESEF = SQRT(EFFHSTES).
C          = FRACTION OF ENERGY IN HW-STES ADDED TO/REMOVED FROM
C            HW-STES THAT IS NOT LOST, DUE TO T&D LOSSES
C            APPLY SEPARATELY DURING CHARGING AND DISCHARGING.
C STORHTWH = MAX STORAGE CAPACITY (TWH) OF HW-STES STORAGE
C STORHCUR = CURRENT ENERGY (TWH) AVAILABLE IN HW-STES STORAGE
C HTSTOR   = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) HW-STES STORAGE
C            EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C            IN AND OUT OF HW-STES STORAGE
C HTSTLI   = CUM ENERGY LOSS COMING INTO HW-STES STORAGE ONLY OVER YEAR (TWH)
C            FOR EACH 1..24 GMT HR
C
         HWADD                = MIN(EXCESS   * RTHTESEF,
     1                             HOTCHARG * PERHRS(J) * RTHTESEF,
     1                             STORHTWH - STORHCUR)
         STORHCUR              = STORHCUR + HWADD
         HWLOSS                = HWADD / RTHTESEF - HWADD
         HTSTOR(IGMTH,IGMTD)   = HTSTOR(IGMTH,IGMTD) + HWADD
         HTSTLI(IGMTH,IGMTD)   = HTSTLI(IGMTH,IGMTD) + HWLOSS
         EXCESS                = MAX(EXCESS - HWADD - HWLOSS,0.)
C
C ***********************************************************************
C  STORE EXCESS ELECTRICITY NEXT IN UNDERGROUND (UTES) HEAT STORAGE
C              EITHER IN BOREHOLES, WATER PITS, OR AQUIFERS
C ***********************************************************************
C
         UGADD                = MIN(EXCESS    * RTUGEFF,
     1                             UTESCHARG * PERHRS(J) * RTUGEFF,
     1                             UTESTWH   - UGSTORCUR)
         UGSTORCUR             = UGSTORCUR + UGADD
         UGLOSS                = UGADD / RTUGEFF - UGADD
         UGSTOR(IGMTH,IGMTD)   = UGSTOR(IGMTH,IGMTD) + UGADD
         UGSTLI(IGMTH,IGMTD)   = UGSTLI(IGMTH,IGMTD) + UGLOSS
         EXCESS                = MAX(EXCESS - UGADD - UGLOSS,0.)
C
C ***********************************************************************
C        USE EXCESS ELECTRICITY NEXT TO PRODUCE/COMPRESS/STORE H2
C                         FOR NON-GRID PURPOSES
C ***********************************************************************
C H2STORMX  = MAXIMUM STORAGE (TWH) AVAILABLE FOR NON-GRID H2 AT GIVEN TIME
C H2CURSTOR = CUR STORED NON-GRID H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2)
C H2CURMAX  = MAX TWH-ELEC USED TO PRODUCE/COMPRESS/STORE H2 DURING SIM
C H2PEAKLD  = LARGEST INSTANT NON-GRID H2 PRODUCTION LOAD (TW) ALLOWED
C             VIA ELECTROLYZERS/COMPRESSORS FOR NON-GRID H2 WHEN IMERGH2=0 OR
C             2 AND GRID PLUS NON-GRID H2 WHEN IMERGH2=1,3
C             ENSURE H2PEAKLD IS AT LEAST AS BIG AS FCCHARG WHEN IMERGH2=1,3
C H2TCUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR NON-GRID STORAGE WHEN IMERGH2=0 OR NON-GRID + GRID STORAGE
C             WHEN IMERGH2=1,3
C EXCESS    = EXCESS ENERGY (TWH) AVAILABLE TO BE USED FOR H2
C ADDH2     = EXCESS ENERGY (TWH) USED FOR H2, BUT WITH LIMITS
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR H2 ELECTROLYSIS+COMPRESSION OVER SIM
C IMERGH2   = 0: DO NOT INCLUDE ANY H2 FOR GRID ELECTRICITY
C           = 1: MERGE ELECTROLYZERS, COMPRESSORS, & STORAGE FOR
C                GRID AND NON-GRID H2.
C           = 2: KEEP ELECTROLYZERS, COMPRESSORS, & STORAGE
C                SEPARATE FOR GRID VERSUS NON-GRID H2
C           = 3: SAME AS IMERGH2=1, EXCEPT BATDISCH=0 (NO BATTERIES
C             DO NOT PERFORM CAL WHEN IMERGH2=1,3 SINCE ALREADY
C             PERFORMED ABOVE FOR THAT CASE
C
         IF (IMERGH2.EQ.0.OR.IMERGH2.EQ.2.OR.FCCHARG.EQ.0.) THEN
          ADDH2                = MIN(EXCESS,MAX(H2STORMX-H2CURSTOR,0.),
     1                               H2PEAKLD*PERHRS(J))
          H2CURSTOR            = H2CURSTOR            + ADDH2
          H2STOR( IGMTH,IGMTD) = H2STOR( IGMTH,IGMTD) + ADDH2
          ENSHED               = MAX(EXCESS - ADDH2,0.)
          H2CURMAX             = MAX(H2CURSTOR,H2CURMAX)
          H2LDPEAKI            = MAX(H2LDPEAKI,ADDH2/PERHRS(J))
          H2TCUMTWH            = H2TCUMTWH            + ADDH2
         ELSE
          ENSHED               = EXCESS
         ENDIF
C
C ***********************************************************************
```

```
C                  SHED REMAINING EXCESS ELECTRICITY
C ***********************************************************************
C CUMSHED  = CUM WIND+SOLAR CURTAILED (TWH) OVER SIMULATION
C HRSHED   = WIND+SOLAR CURTAILED (TWH) EACH HOUR WHEN EXCESS SUPPLY & STORAGE FILLED
C
         HRSHED(IGMTH,IGMTD) = HRSHED(IGMTH,IGMTD) + ENSHED
         CUMSHED             = CUMSHED             + ENSHED
C
        ELSE
         WRITE(IOUT,*)'POWERWORLD4',TIMWWS(J),SUPPLY(J),
     1                             DEMAND(J),DEMANDNEW
         STOP
        ENDIF
C       ENDIF DEMINFLEX>SUPPLY
C
C TWHDEMAND = TWH OF ELECTRIC POWER INFLEX+FLEXIBLE LOAD DURING SIMULATION.
C             THIS DOES NOT INCLUDE TWHSTORH2, TWHSHEAT, TWHSCOLD OR TWHSHIGHT
C             BUT INCLUDES TWHELECH2, TWHEHEAT, TWHECOLD, TWHEHIGHT
C HRFLXLD   = CUM FLEXIBLE LOAD EACH DAY OF YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER DEMAND-RESPONSE MANAGEMENT ACCOUNTED FOR.
C             INLCLUDES FLEXIBLE LOAD SUPPLIED BY COLD STORAGE, HEAT STORAGE,
C             SOLAR+GEOTHERMAL HEAT, AND ALL ELECTRICITY
C ADDDEM    = FLEXIBLE ELEC DEMAND (TWH) SATISFIED BY EITHER CURRENT SUPPLY
C             IN EXCESS OF INFLEXIBLE DEMAND OR BY STORAGE DURING A TIME STEP.
C
        TWHDEMAND           = TWHDEMAND + DEMINFLEX + ADDDEM
        HRFLXLD(IGMTH,IGMTD) = HRFLXLD(IGMTH,IGMTD)  + ADDDEM
C
C ***********************************************************************
C  REDUCE FLEXIBLE LOADS FROM PREVIOUS 1..MXHRDRM HOURS FROM OLDEST
C  TO NEWEST. REMAINDEM HAS ALREADY BEEN REDUCED, SO REMAINHR
C  MUST BE REDUCED BY THE EXACT SAME AMOUNT
C ***********************************************************************
C REMAINHR = REMAINING FLEXIBLE LOAD (TWH) THAT MUST BE MET IN A GIVEN DAY,
C            FOR EACH GMT HOUR OF THE SIMULATION. THE SUM OF REMAINHR
C            OVER ALL HOURS EQUAL REMAINDEM AT ANY POINT.
C ADDDEM   = DEMAND (TWH) FROM FLEXIBLE LOADS (TRANSPORT/INDUSTRY) ADDED
C            TO CURRENT DEMAND AND SATISFIED FROM STORAGE DURING CUR TIME STEP
C REMFLEX  = TWH OF LOAD FROM PREVIOUS 1..MXHRDRM HOUR SATISFIED FROM
C            CURRENT TIME STEP SUPPLY
C            SUM OF REMFLEX OVER ALL 1..MXHRDRM HOURS = ADDDEM
C REDREMAIN = ADDDEM, REDUCED BY REMFLEX EACH 1..MXHRDRM HOUR BACKWARDS.
C             IN THE END, IT SHOULD EQUAL 0.
C MXHRDRM   = MAX NUMBER OF HOURS FORWARD THAT LOAD CAN BE SHIFTED BY
C             DEMAND-RESPONSE MANAGEMENT
C
        IF (ADDDEM.GT.0.) THEN
         MXHRBACK            = MIN0(MXHRDRM,JGMTH-1)
         REDREMAIN           = ADDDEM
         DO I                = MXHRBACK, 0, -1
          JGMTPREV           = JGMTH - I
          REMFLEX            = MIN(REDREMAIN,REMAINHR(JGMTPREV))
          REMAINHR(JGMTPREV) = REMAINHR(JGMTPREV) - REMFLEX
          REDREMAIN          = REDREMAIN          - REMFLEX
         ENDDO
C
        ENDIF
C
       ENDIF
C      ENDIF TIMWWS<TIMLOAD(MXLOADYR)
 250  CONTINUE
C     CONTINUE J = 1, IWWS
C
C ***********************************************************************
C                        PRINT FINAL OUTPUT
C ***********************************************************************
C HRCNT    = NUMBER OF HOURS OF SIMULATION FOR EACH GMT HOUR 1..24
C HRINFLX  = INFLEXIBLE ELEC LOAD EACH DAY OF SIM (TWH) FOR EACH 1..24 GMT HOUR
C            INCLUDES INLEXIBLE LOADS UNSATISFIED BY HEAT+COLD STORAGE THAT MUST
C            BE MET IMMEDIATELY BY ELECTRICITY.
C HRFLXLD  = CUM FLEXIBLE LOAD EACH DAY OF YEAR (TWH) FOR EACH 1..24 GMT HOUR
C            AFTER DEMAND-RESPONSE MANAGEMENT ACCOUNTED FOR.
C            INLCLUDES FLEXIBLE LOAD SUPPLIED BY COLD STORAGE, HEAT STORAGE,
C            SOLAR+GEOTHERMAL HEAT, AND ALL ELECTRICITY
C ORIGLD   = INFLEX+FLEXIBLE (FLEXLOAD+COLDTWH+WARMTWH+FLEXH2LD) LOAD
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C             EACH HOUR OF SIM (TWH) FOR EACH 1..24 GMT
C             HOURS BEFORE SHIFTING TIME OF LOAD DUE TO DEMAND RESPONSE
C HRONWIN   = CUM ONSHORE WIND PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HROFFWD   = CUM OFFSHORE WIND PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRROOF    = CUM ROOF PV PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRUTPV    = CUM UTIL PV PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRCSP     = CUM CSP PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRWAVE    = CUM WAVE POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             AFTER T&D LOSSES
C HRGEOT    = CUM GEOT POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             AFTER T&D LOSSES
C HRTIDE    = CUM TIDE POW PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             AFTER T&D LOSSES
C HRSHT     = CUM SOLAR-HEAT PRODUCTION OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRGHT     = CUM GEOTHERMAL HEAT PROD OVER YEAR (TWH) FOR EACH 1..24 GMT HOUR
C             AFTER T&D LOSSES
C HRSUPP    = CUM WIND+SOLAR+HYDRO+GEO+TIDAL+WAVE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C             THIS IS SUPPLY AFTER T&D LOSSES ARE TAKEN OUT
C HCSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CSP STORAGE
C             EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST COMING
C             IN AND OUT OF STORAGE
C HCSTLS    = CUM ENERGY LOSS COMING OUT OF CSP STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C HCSTLI    = CUM ENERGY LOSS GOING INTO CSP STORAGE ONLY OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HR
C           = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C HOSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) CW-STES + PCM-ICE
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HOSTLS    = CUM ENERGY LOSS COMING OUT OF CW-STES + PCM-ICE STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C HOSTLI    = CUM ENERGY LOSS GOING INTO CW-STES + PCM-ICE STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C           = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C HBSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) BATTERY
C             STORAGE EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HBSTLS    = CUM ENERGY LOSS COMING OUT OF BATTERY STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C HBSTLI    = CUM ENERGY LOSS GOING INTO BATTERY STORAGE ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C           = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C HFSTOR    = CUM NET TWH ENERGY ADDED TO (+) SUBT FROM (-) H2 STORAGE
C             FOR ELEC EACH 1..24 GMT HR. THIS DOES NOT INCLUDE ENERGY LOST
C             COMING IN AND OUT OF STORAGE
C HFSTLS    = CUM ENERGY LOSS COMING OUT OF H2 STORAGE FOR ELEC OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C HFSTLI    = CUM ENERGY LOSS GOING INTO H2 STORAGE FOR ELEC ONLY OVER
C             YEAR (TWH) FOR EACH 1..24 GMT HR
C           = SAME AS HCSTLS, EXCEPT INCLUDES ONLY LOSSES OF ENERGY INTO
C             STORAGE (THOSE THAT ARE NOT INCLUDED IN STORAGE).
C HRHYDR    = CUM HYDRO PROD EACH 1..24 GMT HR OF YEAR (TWH) AFTER T&D LOSSES
C             DIVIDE BY TDEFFMN(IHYDRO) AT END OT ACCOUNT FOR T&D LOSSES
C HRTDLS    = CUM WIND+SOLAR TRANS&DIST LOSS OVER YEAR (TWH) FOR EACH 1..24 GMT HR
C HRSHED    = WIND+SOLAR CURTAILED (TWH) EACH HOUR WHEN EXCESS SUPPLY & STORAGE FILLED
C CUMSHED   = CUM WIND+SOLAR CURTAILED (TWH) OVER SIMULATION
C H2STOR    = CUM NET TWH ENERGY ADDED TO PRODUCING/COMPRESSING/STORING (+)
C             SUBTRAC FROM USING (-) H2 EACH 1..24 GMT HR. INCL EN FOR LEAKED H2
C H2LOAD    = CUM FLEX H2 LOAD COMING FROM H2 STORAGE OVER YEAR (TWH)
C             FOR EACH 1..24 GMT HOUR
C TSUMHRS   = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C
C WRITE TIME-SERIES TO BOTH IOUT (xx) FILE AND IHOU FILE
C
      WRITE(IHOU,261) 'GMTDAY  ', 'GMTHR'
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      WRITE(IOUT,261) 'GMTDAY  ', 'GMTHR'
C
      WRITE(IMON,261) 'MONTH   ', 'NDMON'
C
      TSUMLOAD  = 0.
      TSUMFLXLD = 0.
      TSUMH2LD  = 0.
      TSUMORIG  = 0.
C
      TSUMCSTLI = 0.
      TSUMCSTLS = 0.
      TSUMCSTOR = 0.
C
      TSUMPSTLI = 0.
      TSUMPSTLS = 0.
      TSUMPSTOR = 0.
C
      TSUMBSTLI = 0.
      TSUMBSTLS = 0.
      TSUMBSTOR = 0.
C
      TSUMFSTLI = 0.
      TSUMFSTLS = 0.
      TSUMFSTOR = 0.
C
      TSUMOSTLI = 0.
      TSUMOSTLS = 0.
      TSUMOSTOR = 0.
C
      TSUMHSTLI = 0.
      TSUMHSTLS = 0.
      TSUMHSTOR = 0.
C
      TSUMUGSTI = 0.
      TSUMUGSTL = 0.
      TSUMUGSTO = 0.
C
      TSUMBRSTI = 0.
      TSUMBRSTL = 0.
      TSUMBRSTO = 0.
C
      TSUMH2STO = 0.
      TSUMSHED  = 0.
      TSUMNLS   = 0.
      TSUPORIG  = 0.
      TSUMWIND  = 0.
      TSUMSOL   = 0.
      TSUMHYD   = 0.
      TSUMWAV   = 0.
      TSUMGEO   = 0.
      TSUMTID   = 0.
      TSUMSHT   = 0.
      TSUMGHT   = 0.
      TSUMTDLS  = 0.
      TSUMSUPP  = 0.
      TSUMCOLD  = 0.
      TSUMWARM  = 0.
      TSUMHRS   = 0.
C
C SUMLOAD  = TOTAL INFLEXIBLE LOAD (TWH) FOR EACH MONTH
C SUMFLXLD = TOTAL FLEXIBLE LOAD (TWH) FOR EACH MONTH
C SUMH2LD  = TOTAL FLEXIBLE H2 LOAD (TWH) COMING FROM H2 STORAGE EACH MONTH
C SUMORIG  = TOTAL FLEXIBLE + INFLEXIBLE LOAD (TWH) EACH MONTH BEFORE TIME-
C            SHIFTING OF FLEXIBLE LOAD DUE TO DEMAND RESPONSE MANAGEMENT.
C            TSUMORIG = TSUMLOAD + TSUMFLXLD IN LIMIT OF ENTIRE SIMULATION
C SUMSCTLI = TOTAL LOSS ENERGY GOING INTO CSP STORAGE (TWH) EACH MONTH
C SUMSCTLS = TOTAL LOSS ENERGY GOING INTO+OUT OF CSP STORAGE (TWH) EACH MONTH
C SUMSOTLI = TOTAL LOSS EN GOING INTO CW-STES + PCM-ICE STORAGE (TWH) EACH MONTH
C SUMSOTLS = TOTAL LOSS EN GOING IN+OUT CW-STES + PCM-ICE STORAGE (TWH) EACH MONTH
C SUMSBTLS = TOTAL LOSS EN GOING IN+OUT BATTERY TORAGE (TWH) EACH MONTH
C SUMCSTOR = NET CHANGE IN CSP STORAGE (TWH) AT END OF EACH MONTH
C          = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) CSP STORAGE
C            EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C          = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C SUMOSTOR = NET CHANGE IN CW-STES + PCM-ICE STORAGE (TWH) AT END OF EACH MONTH
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C          = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C            EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C          = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C SUMBSTOR = NET CHANGE IN BATTERY STORAGE (TWH) AT END OF EACH MONTH
C          = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C            EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C          = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C SUMFSTOR = NET CHANGE IN HYDROGEN FOR ELEC STORAGE (TWH) AT END OF EACH MONTH
C          = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C            EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C          = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C SUMUGSTI = TOTAL LOSS OF ENERGY GOING INTO UTES STORAGE (TWH) EACH MONTH
C SUMUGSTL = TOTAL LOSS OF ENERGY GOING INTO+OUT OF UTES STORAGE (TWH) EACH MONTH
C SUMUGSTO = NET CHANGE IN UTES STORAGE (TWH) EACH MONTH
C          = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) UTES STORAGE
C            EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C          = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C SUMBRSTI = TOTAL LOSS OF ENERGY GOING INTO FIREBRICK STORAGE (TWH) EACH MONTH
C SUMBRSTL = TOTAL LOSS OF ENERGY GOING INTO+OUT OF FIREBRICK STORAGE (TWH) EACH MONTH
C SUMBRSTO = NET CHANGE IN FIREBRICK INDUSTRIAL HEAT STORAGE (TWH) EACH MONTH
C SUMH2STO = NET CHANGE IN ENERGY FOR H2 PROD/COMPRESS/STORAGE (TWH) EACH MONTH
C SUMSHED  = TOTAL WWS ENERGY CURTAILED DURING EACH MONTH (TWH)
C SUMNLS   = MONTHLY FLEX+INFLEX DEMAND (TWH) + STORAGE LOSSES + STORAGE
C          + WIND+SOLAR CURTAILED DURING DAY + T&D LOSSES.  SUMNLS SHOULD = SUPORIG
C SUPORIG  = MONTHLY SUPPLY (TWH) OF ALL ELEC+HEAT BEFORE T&D LOSSES=SUMNLS
C SUMWIND  = WIND SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMSOL   = SOLAR-ELEC SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMHYD   = HYDROELEC SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMWAV   = WAVE ELEC SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMGEO   = GEOTHERMAL ELEC SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMTID   = TIDAL ELEC SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMSHT   = SOLAR-HEAT SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMGHT   = GEOTHERMAL HEAT SUPPLY (TWH) OVER EACH MONTH BEFORE T&D LOSSES
C SUMTDLS  = TRANSMISSIO & DISTRIBUTION LOSSES (T&D) EACH MONTH
C SUMSUPP  = SUPPLY (TWH) OF WIND+SOLAR AFTER T&D LOSSES EACH MONTH
C IGMTM    = 1..MXMONTH*NYEARS MONTH CORRESPONDING TO EACH GMT DAY OF SIMULATION
C TDEFFMN  = 1-TDLOSMN = TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C
      MONLAST   = 0
      NDMONTH   = 0
      HIRATIOS  = 0.
      HIRATIOD  = 0.
C
      DO J      = 1, MXDAY
       MONCUR   = IGMTM(J)

       IF (MONCUR.NE.MONLAST) THEN
        MONLAST  = MONCUR
        NDMONTH  = 0
        SUMLOAD  = 0.
        SUMFLXLD = 0.
        SUMH2LD  = 0.
        SUMORIG  = 0.
C
        SUMCSTLI = 0.
        SUMCSTLS = 0.
        SUMCSTOR = 0.
C
        SUMPSTLI = 0.
        SUMPSTLS = 0.
        SUMPSTOR = 0.
C
        SUMBSTLI = 0.
        SUMBSTLS = 0.
        SUMBSTOR = 0.
C
        SUMFSTLI = 0.
        SUMFSTLS = 0.
        SUMFSTOR = 0.
C
        SUMOSTLI = 0.
        SUMOSTLS = 0.
        SUMOSTOR = 0.
C
        SUMHSTLI = 0.
```

```
        SUMHSTLS = 0.
        SUMHSTOR = 0.
C
        SUMUGSTI = 0.
        SUMUGSTL = 0.
        SUMUGSTO = 0.
C
        SUMBRSTI = 0.
        SUMBRSTL = 0.
        SUMBRSTO = 0.
C
        SUMH2STO  = 0.
        SUMSHED   = 0.
        SUMNLS    = 0.
        SUPORIG   = 0.
        SUMWIND   = 0.
        SUMSOL    = 0.
        SUMHYD    = 0.
        SUMWAV    = 0.
        SUMGEO    = 0.
        SUMTID    = 0.
        SUMSHT    = 0.
        SUMGHT    = 0.
        SUMTDLS   = 0.
        SUMSUPP   = 0.
        SUMLDCOLD = 0.
        SUMLDWARM = 0.
        SUMHRS    = 0.
       ENDIF
C
C NDMONTH  = NUMBER OF DAYS IN CURRENT MONTH
C DAYFT    = DAY OF YEAR AS FRACTION. TIMES ARE MIDPOINT OF EACH HOUR
C
       NDMONTH  = NDMONTH + 1
C
       DO I     = 1, MXHPDAY
        DAYFT   = FLOAT(J) + (I-0.5)/MXHPDAY
C
C ***********************************************************************
C                     WRITE TO MAIN xx FILE
C ***********************************************************************
C
        WRITE(IOUT,262) 'X', DAYFT, I,
C
C INFLEXIBLE ELECTRIC LOAD + PORTION OF UNSATISFIED HEAT+COLD LOAD THAT MUST
C BE MET IMMEDIATELY BY ELECTRICITY.
C
     1                       HRINFLX(I,J),
C
C FLEXIBLE ELECTRIC + HEAT + COLD LOAD MET BY CURRENT ENERGY (INCLUDING
C SOLAR+GEOTHERMAL HEAT) + BY STORAGE
C
     1                       HRFLXLD(I,J),
C
C H2 LOAD MET BY ELECTRICITY
     1                       H2LOAD( I,J),
C
C TOTAL FLEXIBLE+H2 LOAD
     1                       HRFLXLD(I,J) + H2LOAD(I,J),
C
C TOTAL LOAD (INFLEXIBLE + FLEXIBLE + H2)
C
     1                       HRINFLX(I,J) + HRFLXLD(I,J) + H2LOAD(I,J),
C
C INFLEX+FLEXIBLE (FLEXLOAD+COLDTWH+WARMTWH+FLEXH2LD) LOAD BEFORE
C SHIFTING TOME OF LOAD DUE TO DEMAND RESPONSE
C
     1                       ORIGLD( I,J),
C
C LOSSES INTO ALL STORAGE
     1                       HCSTLI( I,J) + PHSTLI(I,J) + HBSTLI(I,J)
     1                     + HOSTLI( I,J) + HTSTLI(I,J) + UGSTLI(I,J),
C
C LOSSES INTO AND OUT OF ALL STORAGE
     1                       HCSTLI( I,J) + HCSTLS(I,J)
```

```
     1                     + PHSTLI( I,J) + PHSTLS(I,J)
     1                     + HBSTLI( I,J) + HBSTLS(I,J)
     1                     + HFSTLI( I,J) + HFSTLS(I,J)
     1                     + HOSTLI( I,J) + HOSTLS(I,J)
     1                     + HTSTLI( I,J) + HTSTLS(I,J)
     1                     + UGSTLI( I,J) + UGSTLS(I,J),
     1                     + BRSTLI( I,J) + BRSTLS(I,J),
C
C CHANGES IN ALL STORAGE (+ IS ADDITION TO STORAGE)
     1                       HCSTOR( I,J) - HCSTLS(I,J)
     1                     + PHSTOR( I,J) - PHSTLS(I,J)
     1                     + HBSTOR( I,J) - HBSTLS(I,J)
     1                     + HFSTOR( I,J) - HFSTLS(I,J)
     1                     + HOSTOR( I,J) - HOSTLS(I,J)
     1                     + HTSTOR( I,J) - HTSTLS(I,J)
     1                     + UGSTOR( I,J) - UGSTLS(I,J)
     1                     + BRSTOR( I,J) - BRSTLS(I,J)
     1                     + H2STOR( I,J),
C
C LOSSES INTO UTES STORAGE
     1                       UGSTLI( I,J),

C LOSSES INTO+OUT OF UTES STORAGE
     1                       UGSTLI( I,J) + UGSTLS(I,J),
C
C CHANGE IN UTES STORAGE IGNORING LOSSES IN AND OUT OF STORAGE
     1                       UGSTOR( I,J) - UGSTLS(I,J),
C
C CHANGES IN H2 STORAGE.
C
     1                       H2STOR( I,J),
C TOTAL CURTAILED ENERGY
C
     1                       HRSHED( I,J),
C
C TOTAL LOAD+CHANGE IN STORED ENERGY + STORAGE LOSSES + T&D LOSSES + CURTAILED ENERGY
C THIS IS EVERYTHING IN TERMS OF DEMAND
C
     1                       HRINFLX(I,J) + HRFLXLD(I,J)
     1                     + HCSTLI( I,J) + HCSTOR( I,J)
     1                     + PHSTLI( I,J) + PHSTOR( I,J)
     1                     + HBSTLI( I,J) + HBSTOR( I,J)
     1                     + HFSTLI( I,J) + HFSTOR( I,J)
     1                     + HOSTLI( I,J) + HOSTOR( I,J)
     1                     + HTSTLI( I,J) + HTSTOR( I,J)
     1                     + UGSTLI( I,J) + UGSTOR( I,J)
     1                     + BRSTLI( I,J) + BRSTOR( I,J)
     1                     + H2LOAD( I,J) + H2STOR( I,J)
     1                     + HRSHED( I,J) + HRTDLS( I,J),
C
C TOTAL WWS ELECTRICITY+HEAT SUPPLY BEFORE LOSSES
C THIS IS EVERYTHING IN TERMS OF SUPPLY
C
     1                       HRSUPP( I,J) + HRTDLS( I,J),
C
C TOTAL ONSHORE + OFFSHORE WIND SUPPLY
C
     1                       HRONWIN(I,J) / TDEFFMN(IONWIND)
     1                     + HROFFWD(I,J) / TDEFFMN(IOFFWIND),
C
C TOTAL ROOFTOP PV + UTILITY SCALE PV + CSP SUPPLY
C
     1                       HRROOF( I,J) / TDEFFMN(IRESPV)
     1                     + HRUTPV( I,J) / TDEFFMN(IUTILPV)
     1                     + HRCSP(  I,J) / TDEFFMN(ICSPSTOR),
C
C TOTAL HYDRO SUPPLY
     1                       HRHYDR( I,J) / TDEFFMN(IHYDRO),
C
C TOTAL WAVE+GEOTHERMAL+TIDAL SUPPLY
     1                       HRWAVE( I,J) / TDEFFMN(IWAVE)
     1                     + HRGEOT( I,J) / TDEFFMN(IGEOEL)
     1                     + HRTIDE( I,J) / TDEFFMN(ITIDAL),
C
C TOTAL SOLAR HEAT SUPPLY
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     1                       HRSHT(  I,J) / TDEFFMN(ISOLTHM),
C
C TOTAL GEOTHERMAL HEAT SUPPLY
     1                       HRGHT(  I,J) / TDEFFMN(IGEOHT),
C
C TOTAL T&D LOSSES
     1                       HRTDLS( I,J),
C
C TOTAL WWS SUPPLY
     1                       HRSUPP( I,J),
C
C TOTAL COLD LOAD
     1                       COLDHR( I,J),
C
C TOTAL WARM LOAD
     1                       WARMHR( I,J),
C
C NUMBER OF HOURS SIMULATED
     1                       HRCNT(  I,J)
C
C ***********************************************************************
C               WRITE EXACT SAME INFORMATION TO HOURLY FILE
C ***********************************************************************
C
        WRITE(IHOU,262) 'X', DAYFT, I,
C
C INFLEXIBLE ELECTRIC LOAD + PORTION OF UNSATISFIED HEAT+COLD LOAD THAT MUST
C BE MET IMMEDIATELY BY ELECTRICITY.
C
     1                       HRINFLX(I,J),
C
C FLEXIBLE ELECTRIC + HEAT + COLD LOAD MET BY CURRENT ENERGY (INCLUDING
C SOLAR+GEOTHERMAL HEAT) + BY STORAGE
C
     1                       HRFLXLD(I,J),
C
C H2 LOAD MET BY ELECTRICITY
     1                       H2LOAD( I,J),
C
C TOTAL FLEXIBLE+H2 LOAD
     1                       HRFLXLD(I,J) + H2LOAD(I,J),
C
C TOTAL LOAD (INFLEXIBLE + FLEXIBLE + H2)
C
     1                       HRINFLX(I,J) + HRFLXLD(I,J) + H2LOAD(I,J),
C
C INFLEX+FLEXIBLE (FLEXLOAD+COLDTWH+WARMTWH+FLEXH2LD) LOAD BEFORE
C SHIFTING TOME OF LOAD DUE TO DEMAND RESPONSE
C
     1                       ORIGLD( I,J),
C
C LOSSES INTO ALL STORAGE
     1                       HCSTLI( I,J) + PHSTLI(I,J) + HBSTLI(I,J)
     1                     + HOSTLI( I,J) + HTSTLI(I,J) + UGSTLI(I,J),
C
C LOSSES INTO AND OUT OF ALL STORAGE
     1                       HCSTLI( I,J) + HCSTLS(I,J)
     1                     + PHSTLI( I,J) + PHSTLS(I,J)
     1                     + HBSTLI( I,J) + HBSTLS(I,J)
     1                     + HFSTLI( I,J) + HFSTLS(I,J)
     1                     + HOSTLI( I,J) + HOSTLS(I,J)
     1                     + HTSTLI( I,J) + HTSTLS(I,J)
     1                     + UGSTLI( I,J) + UGSTLS(I,J),
     1                     + BRSTLI( I,J) + BRSTLS(I,J),
C
C CHANGES IN ALL STORAGE (+ IS ADDITION TO STORAGE)
     1                       HCSTOR( I,J) - HCSTLS(I,J)
     1                     + PHSTOR( I,J) - PHSTLS(I,J)
     1                     + HBSTOR( I,J) - HBSTLS(I,J)
     1                     + HFSTOR( I,J) - HFSTLS(I,J)
     1                     + HOSTOR( I,J) - HOSTLS(I,J)
     1                     + HTSTOR( I,J) - HTSTLS(I,J)
     1                     + UGSTOR( I,J) - UGSTLS(I,J)
     1                     + BRSTOR( I,J) - BRSTLS(I,J)
     1                     + H2STOR( I,J),
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C
C LOSSES INTO UTES STORAGE
     1                       UGSTLI( I,J),

C LOSSES INTO+OUT OF UTES STORAGE
     1                       UGSTLI( I,J) + UGSTLS(I,J),
C
C CHANGE IN UTES STORAGE IGNORING LOSSES IN AND OUT OF STORAGE
     1                       UGSTOR( I,J) - UGSTLS(I,J),
C
C CHANGES IN H2 STORAGE. TOTAL ENERGGY STHED
C
     1                       H2STOR( I,J),
C TOTAL CURTAILED ENERGY
C
     1                       HRSHED( I,J),
C
C TOTAL LOAD+CHANGE IN STORED ENERGY + STORAGE LOSSES + T&D LOSSES + CURTAILED ENERGY
C THIS IS EVERYTHING IN TERMS OF DEMAND
C
     1                       HRINFLX(I,J) + HRFLXLD(I,J)
     1                     + HCSTLI( I,J) + HCSTOR( I,J)
     1                     + PHSTLI( I,J) + PHSTOR( I,J)
     1                     + HBSTLI( I,J) + HBSTOR( I,J)
     1                     + HFSTLI( I,J) + HFSTOR( I,J)
     1                     + HOSTLI( I,J) + HOSTOR( I,J)
     1                     + HTSTLI( I,J) + HTSTOR( I,J)
     1                     + UGSTLI( I,J) + UGSTOR( I,J)
     1                     + H2LOAD( I,J) + H2STOR( I,J)
     1                     + HRSHED( I,J) + HRTDLS( I,J),
C
C TOTAL WWS ELECTRICITY+HEAT SUPPLY BEFORE LOSSES
C THIS IS EVERYTHING IN TERMS OF SUPPLY
C
     1                       HRSUPP( I,J) + HRTDLS( I,J),
C
C TOTAL ONSHORE + OFFSHORE WIND SUPPLY
C
     1                       HRONWIN(I,J) / TDEFFMN(IONWIND)
     1                     + HROFFWD(I,J) / TDEFFMN(IOFFWIND),
C
C TOTAL ROOFTOP PV + UTILITY SCALE PV + CSP SUPPLY
C   PUT MAXIMUM FOR GRAPHICS WHEN USING LOGARITHMIC VERT AXES
C
     1                       MAX(HRROOF( I,J) / TDEFFMN(IRESPV)
     1                     + HRUTPV( I,J) / TDEFFMN(IUTILPV)
     1                     + HRCSP(  I,J) / TDEFFMN(ICSPSTOR),1.0E-06),
C
C TOTAL HYDRO SUPPLY
     1                       HRHYDR( I,J) / TDEFFMN(IHYDRO),
C
C TOTAL WAVE+GEOTHERMAL+TIDAL ELECTRICITY SUPPLY
     1                       HRWAVE( I,J) / TDEFFMN(IWAVE)
     1                     + HRGEOT( I,J) / TDEFFMN(IGEOEL)
     1                     + HRTIDE( I,J) / TDEFFMN(ITIDAL),
C
C TOTAL SOLAR HEAT SUPPLY
     1                       HRSHT(  I,J) / TDEFFMN(ISOLTHM),
C
C TOTAL GEOTHERMAL HEAT SUPPLY
     1                       HRGHT(  I,J) / TDEFFMN(IGEOHT),
C
C TOTAL T&D LOSSES
     1                       HRTDLS( I,J),
C
C TOTAL WWS SUPPLY
     1                       HRSUPP( I,J),
C
C TOTAL COLD LOAD
C   PUT MAXIMUM FOR GRAPHICS WHEN USING LOGARITHMIC VERT AXES
     1                       MAX(COLDHR( I,J),1.0E-06),
C
C TOTAL WARM LOAD
C   PUT MAXIMUM FOR GRAPHICS WHEN USING LOGARITHMIC VERT AXES
     1                       MAX(WARMHR( I,J),1.0E-06),
```

```
C    1                      WARMHR( I,J),
C
C NUMBER OF HOURS SIMULATED
     1                      HRCNT(  I,J)
C
C ***********************************************************************
C                   SUM STATISTICS FOR CURRENT MONTH
C ***********************************************************************
C
        SUMLOAD   = SUMLOAD   + HRINFLX(I,J)
        SUMFLXLD  = SUMFLXLD  + HRFLXLD(I,J)
        SUMH2LD   = SUMH2LD   + H2LOAD( I,J)
        SUMORIG   = SUMORIG   + ORIGLD( I,J)
C
        SUMCSTLI  = SUMCSTLI  + HCSTLI( I,J)
        SUMCSTLS  = SUMCSTLS  + HCSTLI( I,J) + HCSTLS(I,J)
        SUMCSTOR  = SUMCSTOR  + HCSTOR( I,J) - HCSTLS(I,J)
C
        SUMPSTLI  = SUMPSTLI  + PHSTLI( I,J)
        SUMPSTLS  = SUMPSTLS  + PHSTLI( I,J) + PHSTLS(I,J)
        SUMPSTOR  = SUMPSTOR  + PHSTOR( I,J) - PHSTLS(I,J)
C
        SUMBSTLI  = SUMBSTLI  + HBSTLI( I,J)
        SUMBSTLS  = SUMBSTLS  + HBSTLI( I,J) + HBSTLS(I,J)
        SUMBSTOR  = SUMBSTOR  + HBSTOR( I,J) - HBSTLS(I,J)
C
        SUMFSTLI  = SUMFSTLI  + HFSTLI( I,J)
        SUMFSTLS  = SUMFSTLS  + HFSTLI( I,J) + HFSTLS(I,J)
        SUMFSTOR  = SUMFSTOR  + HFSTOR( I,J) - HFSTLS(I,J)
C
        SUMOSTLI  = SUMOSTLI  + HOSTLI( I,J)
        SUMOSTLS  = SUMOSTLS  + HOSTLI( I,J) + HOSTLS(I,J)
        SUMOSTOR  = SUMOSTOR  + HOSTOR( I,J) - HOSTLS(I,J)
C
        SUMHSTLI  = SUMHSTLI  + HTSTLI( I,J)
        SUMHSTLS  = SUMHSTLS  + HTSTLI( I,J) + HTSTLS(I,J)
        SUMHSTOR  = SUMHSTOR  + HTSTOR( I,J) - HTSTLS(I,J)
C
        SUMUGSTI  = SUMUGSTI  + UGSTLI( I,J)
        SUMUGSTL  = SUMUGSTL  + UGSTLI( I,J) + UGSTLS( I,J)
        SUMUGSTO  = SUMUGSTO  + UGSTOR( I,J) - UGSTLS( I,J)
C
        SUMBRSTI  = SUMBRSTI  + BRSTLI( I,J)
        SUMBRSTL  = SUMBRSTL  + BRSTLI( I,J) + BRSTLS( I,J)
        SUMBRSTO  = SUMBRSTO  + BRSTOR( I,J) - BRSTLS( I,J)
C
        SUMH2STO  = SUMH2STO  + H2STOR( I,J)
        SUMSHED   = SUMSHED   + HRSHED( I,J)
        SUMNLS    = SUMNLS    + HRINFLX(I,J)+HRFLXLD(I,J)
     1                         + HCSTLI( I,J)+PHSTLI(I,J)+HBSTLI( I,J)
     1                         + HOSTLI( I,J)+HTSTLI(I,J)+UGSTLI( I,J)
     1                         + BRSTLI( I,J)
     1                         + HCSTOR( I,J)+PHSTOR(I,J)+HBSTOR( I,J)
     1                         + HOSTOR( I,J)+HTSTOR(I,J)+UGSTOR( I,J)
     1                         + BRSTOR( I,J)
     1                         + H2LOAD( I,J)+H2STOR( I,J)
     1                         + HRSHED( I,J)+HRTDLS(I,J)
        SUPORIG   = SUPORIG   + HRSUPP( I,J)+HRTDLS(I,J)
        SUMWIND   = SUMWIND   + HRONWIN(I,J)/TDEFFMN(IONWIND)
     1                         + HROFFWD(I,J)/TDEFFMN(IOFFWIND)
        SUMSOL    = SUMSOL    + HRROOF( I,J)/TDEFFMN(IRESPV)
     1                         + HRUTPV( I,J)/TDEFFMN(IUTILPV)
     1                         + HRCSP(  I,J)/TDEFFMN(ICSPSTOR)
        SUMHYD    = SUMHYD    + HRHYDR( I,J)/TDEFFMN(IHYDRO)
        SUMWAV    = SUMWAV    + HRWAVE( I,J)/TDEFFMN(IWAVE)
        SUMGEO    = SUMGEO    + HRGEOT( I,J)/TDEFFMN(IGEOEL)
        SUMTID    = SUMTID    + HRTIDE( I,J)/TDEFFMN(ITIDAL)
        SUMSHT    = SUMSHT    + HRSHT(  I,J)/TDEFFMN(ISOLTHM)
        SUMGHT    = SUMGHT    + HRGHT(  I,J)/TDEFFMN(IGEOHT)
        SUMTDLS   = SUMTDLS   + HRTDLS( I,J)
        SUMSUPP   = SUMSUPP   + HRSUPP( I,J)
        SUMLDCOLD = SUMLDCOLD + COLDHR( I,J)
        SUMLDWARM = SUMLDWARM + WARMHR( I,J)
        SUMHRS    = SUMHRS    + HRCNT(  I,J)
C
```

```
C ***********************************************************************
C                SUM STATISTICS FOR WHOLE SIMULATION
C ***********************************************************************
C
        TSUMLOAD  = TSUMLOAD  + HRINFLX(I,J)
        TSUMFLXLD = TSUMFLXLD + HRFLXLD(I,J)
        TSUMH2LD  = TSUMH2LD  + H2LOAD( I,J)
        TSUMORIG  = TSUMORIG  + ORIGLD( I,J)
C
        TSUMCSTLI = TSUMCSTLI + HCSTLI( I,J)
        TSUMCSTLS = TSUMCSTLS + HCSTLI( I,J) + HCSTLS(I,J)
        TSUMCSTOR = TSUMCSTOR + HCSTOR( I,J) - HCSTLS(I,J)
C
        TSUMPSTLI = TSUMPSTLI + PHSTLI( I,J)
        TSUMPSTLS = TSUMPSTLS + PHSTLI( I,J) + PHSTLS(I,J)
        TSUMPSTOR = TSUMPSTOR + PHSTOR( I,J) - PHSTLS(I,J)
C
        TSUMBSTLI = TSUMBSTLI + HBSTLI( I,J)
        TSUMBSTLS = TSUMBSTLS + HBSTLI( I,J) + HBSTLS(I,J)
        TSUMBSTOR = TSUMBSTOR + HBSTOR( I,J) - HBSTLS(I,J)
C
        TSUMFSTLI = TSUMFSTLI + HFSTLI( I,J)
        TSUMFSTLS = TSUMFSTLS + HFSTLI( I,J) + HFSTLS(I,J)
        TSUMFSTOR = TSUMFSTOR + HFSTOR( I,J) - HFSTLS(I,J)
C
        TSUMOSTLI = TSUMOSTLI + HOSTLI( I,J)
        TSUMOSTLS = TSUMOSTLS + HOSTLI( I,J) + HOSTLS(I,J)
        TSUMOSTOR = TSUMOSTOR + HOSTOR( I,J) - HOSTLS(I,J)
C
        TSUMHSTLI = TSUMHSTLI + HTSTLI( I,J)
        TSUMHSTLS = TSUMHSTLS + HTSTLI( I,J) + HTSTLS(I,J)
        TSUMHSTOR = TSUMHSTOR + HTSTOR( I,J) - HTSTLS(I,J)
C
        TSUMUGSTI = TSUMUGSTI + UGSTLI( I,J)
        TSUMUGSTL = TSUMUGSTL + UGSTLI( I,J) + UGSTLS( I,J)
        TSUMUGSTO = TSUMUGSTO + UGSTOR( I,J) - UGSTLS( I,J)
C
        TSUMBRSTI = TSUMBRSTI + BRSTLI( I,J)
        TSUMBRSTL = TSUMBRSTL + BRSTLI( I,J) + BRSTLS( I,J)
        TSUMBRSTO = TSUMBRSTO + BRSTOR( I,J) - BRSTLS( I,J)
C
        TSUMH2STO = TSUMH2STO + H2STOR( I,J)
        TSUMSHED  = TSUMSHED  + HRSHED( I,J)
        TSUMNLS   = TSUMNLS   + HRINFLX(I,J)+HRFLXLD(I,J)
     1                        + HCSTLI( I,J)+PHSTLI(I,J)+HBSTLI( I,J)
     1                        + HOSTLI( I,J)+HTSTLI(I,J)+UGSTLI( I,J)
     1                        + BRSTLI( I,J)
     1                        + HCSTOR( I,J)+PHSTOR(I,J)+HBSTOR( I,J)
     1                        + HOSTOR( I,J)+HTSTOR(I,J)+UGSTOR( I,J)
     1                        + BRSTOR( I,J)
     1                        + H2LOAD( I,J)+H2STOR( I,J)
     1                        + HRSHED( I,J)+HRTDLS(I,J)
        TSUPORIG  = TSUPORIG  + HRSUPP( I,J)+HRTDLS(I,J)
        TSUMWIND  = TSUMWIND  + HRONWIN(I,J)/TDEFFMN(IONWIND)
     1                        + HROFFWD(I,J)/TDEFFMN(IOFFWIND)
        TSUMSOL   = TSUMSOL   + HRROOF( I,J)/TDEFFMN(IRESPV)
     1                        + HRUTPV( I,J)/TDEFFMN(IUTILPV)
     1                        + HRCSP(  I,J)/TDEFFMN(ICSPSTOR)
        TSUMHYD   = TSUMHYD   + HRHYDR( I,J)/TDEFFMN(IHYDRO)
        TSUMWAV   = TSUMWAV   + HRWAVE( I,J)/TDEFFMN(IWAVE)
        TSUMGEO   = TSUMGEO   + HRGEOT( I,J)/TDEFFMN(IGEOEL)
        TSUMTID   = TSUMTID   + HRTIDE( I,J)/TDEFFMN(ITIDAL)
        TSUMSHT   = TSUMSHT   + HRSHT(  I,J)/TDEFFMN(ISOLTHM)
        TSUMGHT   = TSUMGHT   + HRGHT(  I,J)/TDEFFMN(IGEOHT)
        TSUMTDLS  = TSUMTDLS  + HRTDLS( I,J)
        TSUMSUPP  = TSUMSUPP  + HRSUPP( I,J)
        TSUMCOLD  = TSUMCOLD  + COLDHR( I,J)
        TSUMWARM  = TSUMWARM  + WARMHR( I,J)
        TSUMHRS   = TSUMHRS   + HRCNT(  I,J)

C ***********************************************************************
C PRINT RATIO OF PEAK (30 S) TO 1-HOUR AVG SUPPLY & DEMAND IN EACH INTERVAL
C ***********************************************************************
C PKRATIOS = RATIO OF MAX SUPPLY IN 30-S INTERVAL TO THAT IN 1-H INTERVAL
C PKRATIOD = RATIO OF MAX DEMAND IN 30-S INTERVAL TO THAT IN 1-H INTERVAL
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C HIRATIOS = HIGHEST VALUE OF PKRATIOS DURING SIMULATION
C HIRATIOD = HIGHEST VALUE OF PKRATIOD DURING SIMULATION
C TOTSUPP  = TOTAL SUPPLY OF ELECTRICITY+HEAT (TWH) DURING IGMTD INTERVAL
C TOTDEMD  = TOTAL DEMAND FOR ELECTRICITY+HEAT+COLD+H2 (TWH) DURING IGMTD INTERVAL
C            DOES NOT INCLUDE T&D LOSSES, CURTAILED ENERGY, OR ENERGY GOING
C            INTO STORAGE OR ENERGY LOSSES IN & OUT OF STORAGE
C HRCOUNT  = COUNT OF THE NUMBER OF HOURS PER IGMTD TIME INTERVAL
C AVSUPPLY = AVERAGE SUPPLY OF ELEC+HEAT (TWH/H=TW) EACH IGMTD INTERVAL
C AVDEMAND = AVERAGE DEMAND FOR ELEC+HEAT+COLD+H2 (TWH/H=TW) EACH IGMTD INTERVAL
C PKSUPE   = PEAK SUPPLY OF ELECTRICITY (TW) AMONG ANY OF 120 30-SECOND INTERVALS
C            WITHIN EACH IGMTD TIME INTERVAL
C PKDEME   = PEAK DEMAND FOR ELECTRIC+HEAT+COLD+H2 (TW) AMONG ANY OF 120 30-S INTERVALS
C            WITHIN EACH IGMTD TIME INTERVAL
C
        AVSUPPLY = TOTSUPP(I,J) / (HRCOUNT(I,J) + SMAL30)
        AVDEMAND = TOTDEMD(I,J) / (HRCOUNT(I,J) + SMAL30)
        PKRATIOS = PKSUPE( I,J) / (AVSUPPLY+SMAL30)
        PKRATIOD = PKDEME( I,J) / (AVDEMAND+SMAL30)
        HIRATIOS = MAX(HIRATIOS,PKRATIOS)
        HIRATIOD = MAX(HIRATIOD,PKRATIOD)
        WRITE(KHPK,393) J,I,AVSUPPLY,PKSUPE(I,J),PKRATIOS,HIRATIOS,
     1                      AVDEMAND,PKDEME(I,J),PKRATIOD,HIRATIOD
 393    FORMAT('DAY HR AVS-TW 30SMAX-TW RATIO ',I5,I3,2(1PE10.3),
     1         2(0PF10.4),' AVD 30SMAX RATIO ',2(1PE10.3),2(0PF10.4))
       ENDDO
C      ENDDO I = 1, MXHPDAY
C
       IF (IGMTM(J+1).NE.MONCUR) THEN
        FLTMON = FLOAT(MONCUR) - 0.5
        N      = NDMONTH
        TOTFLEX =           SUMFLXLD + SUMH2LD
        TOTLOAD = SUMLOAD + SUMFLXLD + SUMH2LD
C
        WRITE(IMON,262)'X',FLTMON,N,SUMLOAD,SUMFLXLD,SUMH2LD,TOTFLEX,
     1   TOTLOAD,SUMORIG,
     1   SUMCSTLI+SUMPSTLI+SUMBSTLI+SUMFSTLI+SUMOSTLI+SUMHSTLI+SUMUGSTI
     1           +SUMBRSTI,
     1   SUMCSTLS+SUMPSTLS+SUMBSTLS+SUMFSTLS+SUMOSTLS+SUMHSTLS+SUMUGSTL
     1           +SUMBRSTL,
     1   SUMCSTOR+SUMPSTOR+SUMBSTOR+SUMFSTOR+SUMOSTOR+SUMHSTOR+SUMUGSTO
     1           +SUMBRSTO+SUMH2STO,
     1   SUMUGSTI,SUMUGSTL,SUMUGSTO,
     1   SUMH2STO,SUMSHED,SUMNLS,SUPORIG,
     1   SUMWIND,SUMSOL,SUMHYD,
     1   SUMWAV+SUMGEO+SUMTID,
     1   SUMSHT,SUMGHT,SUMTDLS,SUMSUPP,SUMLDCOLD,SUMLDWARM,SUMHRS
       ENDIF
C
      ENDDO
C     ENDDO J = 1, MXDAY
C
C TOTALS - WRITE ONLY TO xx (IOUT) FILE, NOT HOURLY (IHOU) FILES
C SINCE IHOU FILE ONLY FOR PRINTING
C
      TOTFLEX =            TSUMFLXLD + TSUMH2LD
      TOTLOAD = TSUMLOAD + TSUMFLXLD + TSUMH2LD
C
      WRITE(IOUT,262)'X',0.,0,TSUMLOAD,TSUMFLXLD,TSUMH2LD,TOTFLEX,
     1   TOTLOAD,TSUMORIG,
     1   TSUMCSTLI+TSUMPSTLI+TSUMBSTLI+TSUMFSTLI+TSUMOSTLI+TSUMHSTLI
     1            +TSUMUGSTI+TSUMBRSTI,
     1   TSUMCSTLS+TSUMPSTLS+TSUMBSTLS+TSUMFSTLS+TSUMOSTLS+TSUMHSTLS
     1            +TSUMUGSTL+TSUMBRSTL,
     1   TSUMCSTOR+TSUMPSTOR+TSUMBSTOR+TSUMFSTOR+TSUMOSTOR+TSUMHSTOR
     1            +TSUMUGSTO+TSUMBRSTO+TSUMH2STO,
     1   TSUMUGSTI,TSUMUGSTL,TSUMUGSTO,
     1   TSUMH2STO,TSUMSHED,TSUMNLS,TSUPORIG,
     1   TSUMWIND,TSUMSOL,TSUMHYD,
     1   TSUMWAV+TSUMGEO+TSUMTID,
     1   TSUMSHT,TSUMGHT,TSUMTDLS,TSUMSUPP,TSUMCOLD,TSUMWARM,TSUMHRS
      WRITE(IOUT,261) 'GMTDAY  ', 'GMTHR'
C
      WRITE(IOUT,*)
C
C ENDLOAD   = TWH OF ALL ENERGY USED OVER SIMULATION FOR END USE LOADS
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C OUTLSCSP  = TWH LOSS DURING DISCHARGING CSP STORAGE
C OUTLSPHS  = TWH LOSS DURING DISCHARGING PHS STORAGE
C OUTLSBAT  = TWH LOSS DURING DISCHARGING BATTERY STORAGE
C OUTLSH2E  = TWH LOSS DURING DISCHARGING H2 FUEL CELLS FOR ELEC STORAGE
C OUTLCOLD  = TWH LOSS DURING DISCHARGING CW-STES+PCM-ICE STORAGE
C OUTLWARM  = TWH LOSS DURING DISCHARGING HW-STES STORAGE
C OUTLSUGS  = TWH LOSS DURING DISCHARGING UTES STORAGE
C TSUMCSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING CSP STORAGE
C TSUMPSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING PHS STORAGE
C TSUMBSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING BATTERY STORAGE
C TSUMOSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING CW-STES+PCM-ICE STOR
C TSUMHSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING HW-STES STORAGE
C TSUMUGSTL = TWH LOSS DURING CHARGING+DISCHARGING+STORING UTES STORAGE
C TSUMBRSTL = TWH LOSS DURING CHARGING+DISCHARGING+STORING BRICK IND HEAT STORAGE
C ALLLOSSES = TWH OF ALL ENERGY LOST IN/OUT STORAGE, CURTAILED, OR T&D LOSSES
C ALLENERGY = TWH ALL ENERGY EITHER USED FOR END USES OR LOST
C PERCLOSS  = PERCENT OF ALLENERGY THAT WAS LOST
C
      ENDLOAD    = TSUMLOAD  + TSUMFLXLD + TSUMH2LD
      OUTLSCSP   = TSUMCSTLS - TSUMCSTLI
      OUTLSPHS   = TSUMPSTLS - TSUMPSTLI
      OUTLSBAT   = TSUMBSTLS - TSUMBSTLI
      OUTLSH2E   = TSUMFSTLS - TSUMFSTLI
      OUTLCOLD   = TSUMOSTLS - TSUMOSTLI
      OUTLWARM   = TSUMHSTLS - TSUMHSTLI
      OUTLSUGS   = TSUMUGSTL - TSUMUGSTI
      OUTLSBRS   = TSUMBRSTL - TSUMBRSTI
      ALLLOSSES  = TSUMCSTLS + TSUMPSTLS + TSUMBSTLS + TSUMFSTLS
     1           + TSUMOSTLS + TSUMHSTLS + TSUMUGSTL + TSUMBRSTL
     1           + TSUMSHED  + TSUMTDLS
      ALLENERGY  = ENDLOAD   + ALLLOSSES
      PERCLOSS   = PCT*ALLLOSSES / ALLENERGY
C
C TSUMWIND  = TWH ON+OFFSHORE WIND PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMSOL   = TWH SOL PV+CSP PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMHYD   = TWH HYDROELECTRIC PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMWAV   = TWH WAVE PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMGEO   = TWH GEOTHERMAL ELECTRICITY PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMTID   = TWH TIDAL PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMSHT   = TWH SOL FLUID HEAT PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMGHT   = TWH GEOTHERMAL HEAT PRODUCED DURING SIM BEFORE T&D LOSS
C CHANGCSPS = TWH LOSS (+) OR GAIN (-) IN CSP STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = STORCINIT - STORCCUR  = HCSTLS - HCSTOR = -TSUMCSTOR
C CHANGPHSS = TWH LOSS (+) OR GAIN (-) IN PHS STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = STORPINIT - STORPCUR  = HPSTLS - HPSTOR = -TSUMPSTOR
C CHANGBATS = TWH LOSS (+) OR GAIN (-) IN BATTERY STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = STORBINIT - STORBCUR  = HBSTLS - HBSTOR = -TSUMBSTOR
C CHANGHELS = TWH LOSS (+) OR GAIN (-) IN H2 ELEC STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = STORFINIT - STORFCUR  = HFSTLS - HFSTOR = -TSUMFSTOR
C CHANGCOLD = TWH LOSS (+) OR GAIN (-) IN CW-STES + PCM-ICE STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = STOROINIT - STOROCUR  = HOSTLS - HOSTOR = -TSUMOSTOR
C CHANGWARM = TWH LOSS (+) OR GAIN (-) IN HW-STES STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
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C             FROM STORAGE
C           = STORHINIT - STORHCUR  = HTSTLS - HTSTOR = -TSUMHSTOR
C TSUMCSTOR = NET CHANGE IN CSP STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) CSP STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMOSTOR = NET CHANGE IN CW-STES + PCM-ICE STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMBSTOR = NET CHANGE IN BATTERY STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C CHANGUTES = TWH LOSS (+) OR GAIN (-) IN UTES STORAGE BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = UGSTINIT - UGSTORCUR = TSUMUGSTL - TSUMUGSTI
C CHANGBRCK = TWH LOSS (+) OR GAIN (-) IN BRICK INDUSTRIAL HEAT STOR BETWEEN
C             BEGIN & END OF SIM. A LOSS MEANS ENERGY WAS DRAWN
C             FROM STORAGE DURING SIMULATION SO MUST BE ADDED
C             TO ALLPROD TO OBTAIN TOTAL ENERGY PRODUCED OR OBTAINED
C             FROM STORAGE
C           = BRICKINIT - BRSTORCUR = TSUMBRSTL - TSUMBRSTI
C CHANGH2S  = TWH LOSS (+) OR GAIN (-) IN H2 STORAGE BETWEEN BEGIN AND END
C             OF SIMULATION. A LOSS MEANS MORE H2 (THUS ENERGY PRODUCING/
C             COMPRESSING/STORING H2) WAS USED FROM STORAGE THAN ADDED.
C           = H2STINIT - H2CURSTOR
C H2CURSTOR = CUR STORED H2 (TWH-ELECTRICITY USED TO PRODUCE/COMPRESS/STORE H2)
C H2STINIT  = INITIAL STORED H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE/H2)
C CHANGSTOR = TWH LOSS (+) OR GAIN (-) IN ALL STORAGE BETWEEN BEGIN&END OF SIM
C           = CHANGNUGS + CHANUGS
C ALLPROD   = TOTAL ENERGY PRODUCED (BEFORE T&D LOSSES) OR OBTAINED
C             FROM STORAGE DURING SIMULATION
C
      CHANGCSPS  = STORCINIT - STORCCUR
      CHANGPHSS  = STORPINIT - STORPCUR
      CHANGBATS  = STORBINIT - STORBCUR
      CHANGHELS  = STORFINIT - STORFCUR
      CHANGCOLD  = STOROINIT - STOROCUR
      CHANGWARM  = STORHINIT - STORHCUR
      CHANGUTES  = UGSTINIT  - UGSTORCUR
      CHANGBRCK  = BRICKINIT - BRSTORCUR
      CHANGH2S   = H2STINIT  - H2CURSTOR
C
      CHANGSTOR  = CHANGCSPS+CHANGPHSS+CHANGBATS+CHANGHELS+CHANGCOLD
     1           + CHANGWARM+CHANGUTES+CHANGBRCK+CHANGH2S
C
      ALLPROD    = TSUMSUPP + TSUMTDLS + CHANGSTOR
C
C ******************************************************************************
C    CALCULATE USE FACTOR OF ELECTROLYZER/COMPRESSOR FOR H2 PRODUCTION FOR
C     NOT GRID-ELECTRICITY STORAGE PURPOSES OF H2 (TRANSPORT, INDUSTRY)
C ******************************************************************************
C YEARSIM   = ACTUAL YEARS OF SIMULATIOM = TSUMHRS / HRSPYR
C TSUMHRS   = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C ELECOTH   = TWH OF ELECTRICITY USED FOR ALL PURPOSES EXCEPT H2, ELEC HEAT LOAD,
C             OR ELEC COOLING LOAD
C TWHDEMAND = TWH OF ELECTRIC POWER INFLEX+FLEXIBLE LOAD DURING SIMULATION.
C             THIS DOES NOT INCLUDE TWHSTORH2, TWHSHEAT, TWHSCOLD OR TWHSHIGHT
C             BUT INCLUDES TWHELECH2, TWHEHEAT, TWHECOLD, TWHEHIGHT
C TWHELECH2 = TWH OF NON-GRID H2 LOAD MET BY H2 PRODUCED FROM CURRENT ELECTRICITY
C TWHEHEAT  = TOTAL HEAT LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY OR
C             DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C TWHECOLD  = TOTAL COLD LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY OR
C             DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C TWHEHIGHT = TOTAL HI-T IND LOAD (TWH) MET BY ELECTRICITY (EITHER IMMEDIATELY
C             OR DELAYED BY DEMAND RESPONSE) OVER SIMULATION
C ALLELECH2 = TWH OF ELECTRICITY USED FOR NON-GRID H2 PRODUC/COMPRES/STORAGE DURING SIM
C TWHSTORH2 = TWH OF H2 LOAD MET BY H2 PREVIOUSLY IN STORAGE
C ALLELECHT = TWH OF ELECTRICITY + HEAT + COLD FOR ALL PURPOSES. SHOULD = ENDLOAD
C TWHSHEAT  = TOTAL HEAT LOAD (TWH) MET BY HEAT STORAGE (HW-STES+UTES) DURING SIM
C           = SUM OF FLEXHEAT OVER SIMULATION
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C             REMAINING HEAT LOAD IS MET BY ELECTRICITY
C TWHSCOLD  = TOTAL COLD LOAD (TWH) MET BY COLD STORAGE (CW-STES+PCM-ICE) DUR SIM
C           = SUM OF FLEXCOLD OVER SIMULATION
C             REMAINING COLD LOAD IS MET BY ELECTRICITY
C TWHSHIGHT = TOTAL LOAD (TWH) MET BY HI-T BRICK STORAGE DURING SIM
C           = SUM OF HITFROMST OVER SIMULATION
C             REMAINING HI-T LOAD IS MET BY ELECTRICITY
C
      YEARSIM   = TSUMHRS   / HRSPYR
      ELECOTH   = TWHDEMAND - TWHELECH2 - TWHEHEAT - TWHECOLD -TWHEHIGHT
      ALLELECH2 = TWHSTORH2 + TWHELECH2
      ALLELECHT = TWHDEMAND + TWHSTORH2 + TWHSHEAT + TWHSCOLD +TWHSHIGHT
C
C H2LDMEAN  = MEAN NON-GRID H2 LOAD (TW) OVER ENTIRE SIM = TLOADH2 WHEN IMERGH2=0 OR 2
C           = MEAN GRID+NON-GRID H2 LOAD(TW) OVER SIM WHEN IMERGH2=1,3
C             LOAD USED TO FOR ELECTROLYZERS/COMPRESSORS
C H2TCUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR NON-GRID STORAGE WHEN IMERGH2=0 OR NON-GRID + GRID STORAGE
C             WHEN IMERGH2=1,3
C H2STINIT  = INITIAL STORED H2 (TWH-ELEC USED TO PRODUCE/COMPRESS/STORE/H2)
C H2CURSTOR = CUR STORED H2 (TWH-ELECTRICITY USED TO PRODUCE/COMPRESS/STORE H2)
C H2PRODTOT = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
C           = H2PYNONG WHEN IMERGH2=0 OR 2
C H2ENERGY  = KWH/KG-H2-PRODUCED-AND-COMPRESSED (=TWH/TG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C
      H2LDMEAN  = (H2TCUMTWH + H2STINIT - H2CURSTOR) / TSUMHRS
      H2PRODTOT = H2LDMEAN * HRSPYR / H2ENERGY
C
C H2LDPEAKI = 0 IF NO H2 STORAGE (DAYH2STOR = 0.)
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR H2 ELECTROLYSIS+COMPRESSION OVER SIM
C H2USEFACI = AVERAGE USE FACTOR (FRACTION) OF ELECTROLYZER/COMPRESSORS FOR
C             PRODUCING H2 FOR NON-GRID-H2 USES (TRANSPORT / INDUSTY)
C             WHEN IMERGH2=0 AND GRID+NON-GRID H2 WHEN IMERGH2=1,3
C           = (MEAN H2 LOAD / INSTANT PEAK H2 LOAD)
C
      IF (H2LDPEAKI.GT.0.) THEN
       H2USEFACI = MIN(H2LDMEAN / H2LDPEAKI,1.)
      ELSE
       H2USEFACI = SMAL30
      ENDIF
C
C ELYZLOAD  = AVG LOAD (TW) REQUIRED FOR ALL ELECTROLYZERS FOR NON-GRID H2
C COMPLOAD  = AVG LOAD (TW) REQUIRED FOR ALL ELECTROLYZERS FOR NON-GRID H2
C H2LDMEAN  = MEAN NON-GRID H2 LOAD (TW) OVER ENTIRE SIM = TLOADH2 WHEN IMERGH2=0 OR 2
C           = MEAN GRID+NON-GRID H2 LOAD(TW) OVER SIM WHEN IMERGH2=1,3
C             LOAD USED TO FOR ELECTROLYZERS/COMPRESSORS
C TLOADH2   = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE=TWHH2TOT/HRSPYR
C           = TGH2PYR * H2ENERGY / HRSPYR
C AKWPTW    = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KG PER TG
C ELECLYZEN = KWH-CONSUMED/KG-H2-PRODUCED BY ELECTROLYZER
C COMPRESEN = KWH-CONSUMED/KG-H2-COMPRESSED BY COMPRESSOR
C H2ENERGY  = KWH/KG-H2-PRODUCED-AND-COMPRESSED (=TWH/TG-H2)
C ELYZKW    = KW OF ELECTROLYZERS NEEDED OVER SIM FOR NON-GRID H2
C             CORRESPONDING TO USE FACTOR H2USEFACI
C ELYZTW    = TW OF ELECTROLYZERS NEEDED OVER SIM FOR NON-GRID H2
C COMPKW    = KW OF COMPRESSORS NEEDED OVER SIM FOR NON-GRID H2
C             CORRESPONDING TO USE FACTOR H2USEFACI
C COMPTW    = TW OF COMPRESSORS NEEDED OVER SIM FOR NON-GRID H2
C H2USEFACI = AVERAGE H2 USE FACTOR FOR NON-GRID H2 (MEAN H2 LOAD/INSTANT PEAK H2 LOAD)
C
      ELYZLOAD  = H2LDMEAN * ELECLYZEN / H2ENERGY
      COMPLOAD  = H2LDMEAN * COMPRESEN / H2ENERGY
      ELYZTW    = ELYZLOAD / H2USEFACI
      ELYZKW    = ELYZTW * AKWPTW
      COMPTW    = COMPLOAD / H2USEFACI
      COMPKW    = COMPTW * AKWPTW
C
C ***************************************************************************
C    CALCULATE USE FACTOR OF ELECTROLYZER/COMPRESSOR FOR H2 PRODUCTION FOR
C                  GRID-ELECTRICITY STORAGE PURPOSE OF H2
C ***************************************************************************
C H2ECUMTWH = CUM ELECTRICITY (TWH) OVER SIM USED TO PRODUCE & COMPRESS
C             H2 FOR GRID ELECTRICITY STORAGE WHEN IMERGH2=2
C FCCHARG   = MAX CHARGE RATE (TW) OF H2 GRID ELEC STORAGE THROUGH ELECTROLYZERS/COMPRESSORS
```

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C TSUMHRS   = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C H2UFGRID  = AVERAGE USE FACTOR (FRACTION )OF ELECTROLYZERS/COMPRESSORS FOR
C             PRODUCING H2 FOR GRID ELECTRICITY
C H2LDMELEC = MEAN POWER (TW) OVER ENTIRE SIM, USED TO PRODUCE H2 FOR
C             ELEC STORAGE BY ELECTROLYZERS/COMPRESSORS
C H2CHAREFF = FRACTION OF ENERGY IN H2FC STORAGE
C             NOT LOST DUE TO T&D LOSSES AND LOSSES CHARGING H2 STORAGE
C H2ENERGY  = TWH/TG-H2-PRODUCED-AND-COMPRESSED (=KWH/KG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C AVHRSPYR  = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C H2PRODGR  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C H2ALLUSED = H2 (TG-H2) USED DURING SIMULATION FOR GRID + NON-GRID USES
C
      ELYZGRTW  = 0.
      ELYZGRKW  = 0.
      COMPGRTW  = 0.
      COMPGRKW  = 0.
C
      IF (IMERGH2.EQ.2) THEN
       IF (FCCHARG.GT.0.) THEN
        H2LDMELEC = H2ECUMTWH / TSUMHRS
        H2UFGRID  = MIN(H2LDMELEC / FCCHARG, 1.)
        H2PRODGR  = H2LDMELEC * HRSPYR / H2ENERGY
        H2ALLUSED = (H2PRODGR + H2PRODTOT) * YEARSIM
C
C AKWPTW    = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KG PER TG
C ELECLYZEN = KWH-CONSUMED/KG-H2-PRODUCED BY ELECTROLYZER
C COMPRESEN = KWH-CONSUMED/KG-H2-COMPRESSED BY COMPRESSOR
C H2ENERGY  = KWH/KG-H2-PRODUCED-AND-COMPRESSED (=TWH/TG-H2)
C ELYZGRKW  = KW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2
C ELYZGRTW  = TW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2
C COMPGRKW  = KW OF COMPRESSORS NEEDED OVER SIM FOR GRID H2
C COMPGRTW  = TW OF COMPRESSORS NEEDED OVER SIM FOR GRID H2
C H2NGUSED  = H2 (TG-H2) USED DURING SIMULATION FOR NON-GRID USES
C H2PYNONG  = TG-H2/YR USED DURING SIM FOR NON-GRID USES = TGH2PYR
C H2PRODGR  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C
        ELYZGRTW  = FCCHARG * ELECLYZEN / H2ENERGY
        ELYZGRKW  = ELYZGRTW * AKWPTW
        COMPGRTW  = FCCHARG * COMPRESEN / H2ENERGY
        COMPGRKW  = COMPGRTW * AKWPTW
       ELSE
        H2LDMELEC = SMAL30
        H2UFGRID  = SMAL30
        H2PRODGR  = SMAL30
        H2ALLUSED = H2PRODTOT * YEARSIM
       ENDIF
C
      ELSEIF (IMERGH2.EQ.0) THEN
       H2LDMELEC = SMAL30
       H2UFGRID  = SMAL30
       H2PRODGR  = SMAL30
       H2ALLUSED = H2PRODTOT * YEARSIM
C
C ELSEIF IMERGH2=1,3
      ELSE
       H2LDMELEC = SMAL30
       H2UFGRID  = SMAL30
       H2NGUSED  = ALLELECH2 / H2ENERGY
       H2PYNONG  = H2NGUSED  / YEARSIM
       H2PRODGR  = MAX(H2PRODTOT - H2PYNONG,0.)
       H2ALLUSED = H2PRODTOT * YEARSIM
      ENDIF
C
C ***************************************************************************
C
C ***************************************************************************
C       CALCULATE USE FACTOR OF H2 FUEL CELL FOR GRID ELECTRICITY USE
C ***************************************************************************
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C H2UFFCELL = AVERAGE USE FACTOR (FRACTION OF FUEL CELL FOR PRODUCING
C             ELECTRICITY FOR GRID FROM STORED OR INSTANT H2
C H2LDFCELL = MEAN POWER (TW) OVER ENTIRE SIM AND AFTER TLOSSES, DISCHARGED FROM FUEL
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C             CELLS FOR GRID ELECTRICITY USE.
C TDISCHHFC = TOTAL EN (TWH) AFTER LOSSES REMOVED FROM H2 STORAGE FOR GRID ELEC DURING SIM
C
      H2LDFCELL = TDISCHHFC / TSUMHRS
C
      IF (FCDISCH.GT.0.) THEN
       H2UFFCELL = MIN(H2LDFCELL / FCDISCH, 1.)
      ELSE
       H2UFFCELL = SMAL30
      ENDIF
C
C *************************************************************************
C                      GENERIC INSTALLATION FACTORS
C *************************************************************************
C FINSTALL  = LOW INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C           = FACTOR TO MULTIPLY CAPITAL COST BY TO ACCOUNT FOR LABOR
C FINSTALH  = HI INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C             https://www.nrel.gov/docs/fy14osti/58564.pdf
C
      FINSTALL  = 1.2
      FINSTALM  = 1.25
      FINSTALH  = 1.3
C
C *************************************************************************
C                         ELECTROLYZER COST
C *************************************************************************
C ELIFEYFL  = ELECTROLYZER+RECTIFIER LIFE (YEARS) WHEN OPERATING AT FULL LOAD (10 Y)
C ECALLIFE  = CALENDAR LIFE OF ELECTROLYZER+RECTIFIER (30 YEARs)
C             https://www.pnnl.gov/sites/default/files/media/file/Hydrogen_Methodology.pdf
C             ASSUME CALENDAR LIFE IN 2035 INCREASES TO 40 YEARS
C
      ELIFEYFL  = 10.
      ECALLIFE  = 40.
C
C ELYZLIFE  = LIFETIME (YR) OF ELECTROLYZER CORRESPONDING TO USE FACTOR H2USEFACI
C             IF USE FACTOR DECREASES, LIFETIME LONGER (UP TO LIMIT
C             ECALLIFE), AND O&M COSTS LOWER.
C ELYZLIFGR = LIFETIME (YR) OF ELECTROLYZER CORRESPONDING TO USE FACTOR H2UFGRID,
C             THUS FOR PRODUCING H2 FOR GRID ELECTRICITY STORAGE
C
      ELYZLIFE  = MIN(ELIFEYFL / H2USEFACI, ECALLIFE)
      ELYZLIFGR = MIN(ELIFEYFL / H2UFGRID,  ECALLIFE)
C
C ELYZFACSL = LO FACTOR (1/YR) TO MULT CAPITAL ELECTROLYZER COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME ELYZLIFE
C ELYZFACSH = HI FACTOR (1/YR) TO MULT CAPITAL ELECTROLYZER COST BY TO GET ANNUAL COST
C DISCOUNTL = LOW SOCIAL DISCOUNT RATE FOR INTER-GENERATIONAL PROJECT
C DISCOUNTH = HI DISCOUNT RATE (FRACTION ON 1 BILLION LOAN)
C
      ELYZTERML  = (1. + DISCOUNTL)**ELYZLIFE
      ELYZTERMM  = (1. + DISCOUNTM)**ELYZLIFE
      ELYZTERMH  = (1. + DISCOUNTH)**ELYZLIFE
C
      ELYZFACSL = DISCOUNTL * ELYZTERML / (ELYZTERML - 1.)
      ELYZFACSM = DISCOUNTM * ELYZTERMM / (ELYZTERMM - 1.)
      ELYZFACSH = DISCOUNTH * ELYZTERMH / (ELYZTERMH - 1.)
C
C ELYZGRFL = LO FACTOR (1/YR) TO MULT CAPITAL ELECTROLYZER COST BY TO GET ANNUAL COST
C            AT DISCOUNT RATE DISCOUNTL AND LIFETIME ELYZLIFGR
C ELYZGRFH = HI FACTOR (1/YR) TO MULT CAPITAL ELECTROLYZER COST BY TO GET ANNUAL COST
C
      ELYZTERML  = (1. + DISCOUNTL)**ELYZLIFGR
      ELYZTERMM  = (1. + DISCOUNTM)**ELYZLIFGR
      ELYZTERMH  = (1. + DISCOUNTH)**ELYZLIFGR
C
      ELYZGRFL = DISCOUNTL * ELYZTERML / (ELYZTERML - 1.)
      ELYZGRFM = DISCOUNTM * ELYZTERMM / (ELYZTERMM - 1.)
      ELYZGRFH = DISCOUNTH * ELYZTERMH / (ELYZTERMH - 1.)
C
C ELYZCOSL  = LOW ELECTROLYZER CAPITAL COST IN 2035 ($/KW)
C ELYZCOSM  = MEAN ELECTROLYZER CAPITAL COST IN 2035 ($/KW)
C ELYZCOSH  = HI  ELECTROLYZER CAPITAL COST IN 2035 ($/KW)
C             PNNL (MONGIRD ET AL., 2020) TABLE 3:
C             $437 (393-481)/KW FOR ELECTROLYZER; $94 (84-103)/KW FOR RECTIFIER
C             https://www.pnnl.gov/sites/default/files/media/file/Hydrogen_Methodology.pdf
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C             PENEV ETAL (2019) HAS $232/KW, 20-YR LIFE, 9% O&M, 57% FINSTAL
C             https://www.nrel.gov/docs/fy19osti/73520.pdf
C
      ELYZCOSL  = 232.
      ELYZCOSH  = 437.
C SENSITIVITY TEST IMERGH2=2 CHINA
C     ELYZCOSL  = 125.
C     ELYZCOSH  = 325.
C
      ELYZCOSM  = 0.5 * (ELYZCOSL + ELYZCOSH)
C
C FINSTALE  = ELECTROLYZER INSTALLATION FACTOR (1.57)
C             PENEV ET AL. (2019) https://www.nrel.gov/docs/fy19osti/73520.pdf AND
C             https://www.hydrogen.energy.gov/pdfs/progress19/ins_sa173_hunter_2019.pdf
C ELYZOM    = FRAC/YR OF ELECTROLYZER PURCHASE COST FOR ANNUAL O&M (7.8%/YR) (PENEV ETAL 2019)
C
C     FINSTALE  = 1.57
      ELYZOM    = 0.078
C
C RECTCOSL = LOW RECTIFIER CAPITAL COST IN 2035
C RECTCOSM = MEAN RECTIFIER CAPITAL COST IN 2035
C RECTCOSH = HIGH RECTIFIER CAPITAL COST IN 2035
C
      RECTCOSL  = 84.
      RECTCOSM  = 94.
      RECTCOSH  = 103.
C
C FINSTALR = RECTIFIER INSTALLATION FACTOR (1.57) (PENEV ET AL, 2019)
C RECTOM   = FRAC/YR OF RECTIFIER PURCHASE COST FOR ANNUAL O&M (1%/YR) (PENEV ETAL 2019)
C
C     FINSTALR  = 1.57
      RECTOM    = 0.01
C
C ANCAPELYZL = LOW  ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR NON-GRID H2 ($/KW-YR)
C ANCAPELYZM = MEAN ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR NON-GRID H2 ($/KW-YR)
C ANCAPELYZH = HIGH ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR NON-GRID H2 ($/KW-YR)
C
      ANCAPELYZL = ELYZCOSL * (FINSTALL*ELYZFACSL + ELYZOM)
     1           + RECTCOSL * (FINSTALL*ELYZFACSL + RECTOM)
      ANCAPELYZM = ELYZCOSM * (FINSTALM*ELYZFACSM + ELYZOM)
     1           + RECTCOSM * (FINSTALM*ELYZFACSM + RECTOM)
      ANCAPELYZH = ELYZCOSH * (FINSTALH*ELYZFACSH + ELYZOM)
     1           + RECTCOSH * (FINSTALH*ELYZFACSH + RECTOM)
C
C ANCOSELYZL = LO ANNUALIZED COST OF ELECTROLYZER+RECTIFIER + O&M ($/KG-H2)
C ANCOSELYZM = MN ANNUALIZED COST OF ELECTROLYZER+RECTIFIER + O&M ($/KG-H2)
C ANCOSELYZH = HI ANNUALIZED COST OF ELECTROLYZER+RECTIFIER + O&M ($/KG-H2)
C H2PRODTOT  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
C            = H2PYNONG WHEN IMERGH2=0 OR 2
C ELYZTW     = TW OF ELECTROLYZERS NEEDED OVER SIM FOR NON-GRID H2
C              CORRESPONDING TO USE FACTOR H2USEFACI
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF ELECTROLYZERS
C              TO H2 PRODUCTION/YR (KG-H2/YR)
C
      H2KWTOKGPY = ELYZTW / H2PRODTOT
      ANCOSELYZL = ANCAPELYZL * H2KWTOKGPY
      ANCOSELYZM = ANCAPELYZM * H2KWTOKGPY
      ANCOSELYZH = ANCAPELYZH * H2KWTOKGPY
C
C ANCAPELYZL = LOW  ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR GRID H2 ($/KW-YR)
C ANCAPELYZM = MEAN ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR GRID H2 ($/KW-YR)
C ANCAPELYZH = HIGH ANNUAL CAP COST OF ELECTROLYZER+RECTIFIER FOR GRID H2 ($/KW-YR)
C
      ANCAPELYZL = ELYZCOSL * (FINSTALL*ELYZGRFL + ELYZOM)
     1           + RECTCOSL * (FINSTALL*ELYZGRFL + RECTOM)
      ANCAPELYZM = ELYZCOSM * (FINSTALM*ELYZGRFM + ELYZOM)
     1           + RECTCOSM * (FINSTALM*ELYZGRFM + RECTOM)
      ANCAPELYZH = ELYZCOSH * (FINSTALH*ELYZGRFH + ELYZOM)
     1           + RECTCOSH * (FINSTALH*ELYZGRFH + RECTOM)
C
C ANCGRELYZL = LO ANNUALIZED COST ELECTROLYZER+RECTIFIER+O&M FOR GRID H2 ($/KG-H2)
C ANCGRELYZM = MN ANNUALIZED COST ELECTROLYZER+RECTIFIER+O&M FOR GRID H2 ($/KG-H2)
C ANCOSELYZH = HI ANNUALIZED COST ELECTROLYZER+RECTIFIER+O&M FOR GRID H2 ($/KG-H2)
C H2PRODGR   = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF ELECTROLYZERS
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```
C              TO H2 PRODUCTION/YR (KG-H2/YR)
C ELYZGRTW   = TW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2

      H2KWTOKGPY = ELYZGRTW / H2PRODGR
      ANCGRELYZL = ANCAPELYZL * H2KWTOKGPY
      ANCGRELYZM = ANCAPELYZM * H2KWTOKGPY
      ANCGRELYZH = ANCAPELYZH * H2KWTOKGPY
C
C CAPELYZL  = ELECTROLYZER+RECTIFIER FOR NON-GRID H2 LOW CAPITAL COST ($TRIL)
C CAPELYZM  = ELECTROLYZER+RECTIFIER FOR NON-GRID H2 MEAN CAPITAL COST ($TRIL)
C CAPELYZH  = ELECTROLYZER+RECTIFIER FOR NON-GRID H2 HIGH CAPITAL COST ($TRIL)
C ELYZCOSL  = LOW ELECTROLYZER CAPITAL COST IN 2050 ($/KW) = $300
C ELYZCOSH  = HI  ELECTROLYZER CAPITAL COST IN 2050 ($/KW) = $450
C ELYZKW    = KW OF ELECTROLYZERS NEEDED OVER SIM FOR NON-GRID H2
C TRILPDOL  = 1.0E-12  TRILLION DOLLARS PER DOLLAR FOR NON-GRID H2
C
      CAPELYZL = (ELYZCOSL+RECTCOSL) * ELYZKW * TRILPDOL
      CAPELYZM = (ELYZCOSM+RECTCOSM) * ELYZKW * TRILPDOL
      CAPELYZH = (ELYZCOSH+RECTCOSH) * ELYZKW * TRILPDOL
C
C CAPGRELYZL  = ELECTROLYZER+RECTIFIER FOR GRID H2 LOW CAPITAL COST ($TRIL)
C CAPGRELYZM  = ELECTROLYZER+RECTIFIER FOR GRID H2 MEAN CAPITAL COST ($TRIL)
C CAPGRELYZH  = ELECTROLYZER+RECTIFIER FOR GRID H2 HIGH CAPITAL COST ($TRIL)
C ELYZGRKW    = KW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2
C
      CAPGRELYZL = (ELYZCOSL+RECTCOSL) * ELYZGRKW * TRILPDOL
      CAPGRELYZM = (ELYZCOSM+RECTCOSM) * ELYZGRKW * TRILPDOL
      CAPGRELYZH = (ELYZCOSH+RECTCOSH) * ELYZGRKW * TRILPDOL
C
C ***************************************************************************
C                          H2 COMPRESSOR COST
C ***************************************************************************
C CCALLIFE  = CALENDAR LIFE OF COMPRESSOR (30 YEAR = ASSUME SAME AS ELECTROLYZER
C             https://www.pnnl.gov/sites/default/files/media/file/Hydrogen_Methodology.pdf
C             ASSUME CALENDAR LIFE IN 2035 INCREASES TO 40 YEARS
C CLIFEYFL  = COMPRESSOR LIFE (YEARS) WHEN OPERATING AT FULL LOAD (10 Y)
C
      CCALLIFE  = 40.
      CLIFEYFL  = 10.
C
C COMPLIFE  = LIFETIME (YR) OF COMPRESSOR CORRESPONDING TO USE FACTOR H2USEFACI
C             IF USE FACTOR DECREASES, LIFETIME LONGER (UP TO LIMIT
C             ECALLIFE), AND O&M COSTS LOWER.
C COMPLIFGR = LIFETIME (YR) OF COMPRESSOR CORRESPONDING TO USE FACTOR H2UFGRID,
C             THUS FOR PRODUCING H2 FOR GRID ELECTRICITY STORAGE
C H2USEFACI = AVERAGE USE FACTOR (FRACTION) OF ELECTROLYZER/COMPRESSORS FOR
C             PRODUCING H2 FOR NON-GRID-ELECTRICITY USES (TRANSPORT / INDUSTY)
C           = (MEAN H2 LOAD / INSTANT PEAK H2 LOAD)
C H2UFGRID  = AVERAGE USE FACTOR (FRACTION) OF ELECTROLYZERS/COMPRESSORS FOR
C             PRODUCING H2 FOR GRID ELECTRICITY
C
      COMPLIFE  = MIN(CLIFEYFL / H2USEFACI, CCALLIFE)
      COMPLIFGR = MIN(CLIFEYFL / H2UFGRID,  CCALLIFE)
C
C COMPFACSL = LO FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME COMPLIFEL
C COMPFACSH = HI FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C
      COMPTERML  = (1. + DISCOUNTL)**COMPLIFE
      COMPTERMM  = (1. + DISCOUNTM)**COMPLIFE
      COMPTERMH  = (1. + DISCOUNTH)**COMPLIFE
C
      COMPFACSL = DISCOUNTL * COMPTERML / (COMPTERML - 1.)
      COMPFACSM = DISCOUNTM * COMPTERMM / (COMPTERMM - 1.)
      COMPFACSH = DISCOUNTH * COMPTERMH / (COMPTERMH - 1.)
C
C COMPFACSL = LO FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME COMPLIFEL
C COMPFACSH = HI FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C
      COMPTERML  = (1. + DISCOUNTL)**COMPLIFGR
      COMPTERMM  = (1. + DISCOUNTM)**COMPLIFGR
      COMPTERMH  = (1. + DISCOUNTH)**COMPLIFGR
C
      COMPFGRL = DISCOUNTL * COMPTERML / (COMPTERML - 1.)
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      COMPFGRM = DISCOUNTM * COMPTERMM / (COMPTERMM - 1.)
      COMPFGRH = DISCOUNTH * COMPTERMH / (COMPTERMH - 1.)
C
C COMCOSLKW = LOW HYDROGEN COMPRESSOR CAPITAL COST (2035)
C COMCOSMKW = MEAN HYDROGEN COMPRESSOR CAPITAL COST (2035)
C COMCOSHKW = HIGH HYDROGEN COMPRESSOR CAPITAL COST (2035)
C             PNNL (MONGIRD ET AL., 2020) TABLE 3:
C             $39.3 (35-43)/KW FOR COMPRESSOR
C             https://www.pnnl.gov/sites/default/files/media/file/Hydrogen_Methodology.pdf
C             THIS CAP COSTS GIVES ~$0.018/KG-H2.
C             ICCT (P.20) ESTIMATES COMPRESSION $0.05-0.1/KG-H2 IN 2020
C https://theicct.org/wp-content/uploads/2021/06/final_icct2020_assessment_of-_hydrogen_production_costs-
v2.pdf1
C
      COMCOSLKW = 35.
      COMCOSMKW = 39.3
      COMCOSHKW = 43.
C
C FINSTALC = COMPRESSOR INSTALLATION FACTOR (1.87) (PENEV ET AL, 2019)
C COMPOM   = FRAC/YR OF COMPRESSOR PURCHASE COST FOR ANNUAL O&M (4%/YR) (PENEV ETAL 2019)
C
      FINSTALC  = 1.87
      COMPOM    = 0.04
C
C ANCAPCOMPL = LOW  ANNUAL CAP + O&M COST OF COMPRESSORS FOR NON-GRID H2 ($/KW-YR)
C ANCAPCOMPM = MEAN ANNUAL CAP + O&M COST OF COMPRESSORS FOR NON-GRID H2 ($/KW-YR)
C ANCAPCOMPH = HIGH ANNUAL CAP + O&M COST OF COMPRESSORS FOR NON-GRID H2 ($/KW-YR)
C FINSTALL   = LOW INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C FINSTALH   = HI INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C
      ANCAPCOMPL = COMCOSLKW * (FINSTALC*COMPFACSL + COMPOM)
      ANCAPCOMPM = COMCOSMKW * (FINSTALC*COMPFACSM + COMPOM)
      ANCAPCOMPH = COMCOSHKW * (FINSTALC*COMPFACSH + COMPOM)
C
C ANCOSCOMPL = LO ANNUALIZED COST OF COMPRESSOR+O&M FOR NON-GRID H2 ($/KG-H2)
C ANCOSCOMPH = HI ANNUALIZED COST OF COMPRESSOR+O&M FOR NON-GRID H2 ($/KG-H2)
C COMPRESEN  = KWH-CONSUMED/KG-H2-COMPRESSED BY COMPRESSOR
C H2PRODTOT  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
C            = H2PYNONG WHEN IMERGH2=0 OR 2
C COMPTW     = TW OF COMPRESSORS NEEDED OVER SIM FOR NON-GRID H2
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF ELECTROLYZERS
C              TO H2 PRODUCTION/YR (KG-H2/YR)
C
      H2KWTOKGPY = COMPTW / H2PRODTOT
      ANCOSCOMPL = ANCAPCOMPL * H2KWTOKGPY
      ANCOSCOMPM = ANCAPCOMPM * H2KWTOKGPY
      ANCOSCOMPH = ANCAPCOMPH * H2KWTOKGPY
C
C ANCAPCOMPL = LOW  ANNUAL CAP + O&M COST OF COMPRESSORS FOR GRID H2 ($/KW-YR)
C ANCAPCOMPM = MEAN ANNUAL CAP + O&M COST OF COMPRESSORS FOR GRID H2 ($/KW-YR)
C ANCAPCOMPH = HIGH ANNUAL CAP + O&M COST OF COMPRESSORS FOR GRID H2 ($/KW-YR)
C
      ANCAPCOMPL = COMCOSLKW * (FINSTALC*COMPFGRL + COMPOM)
      ANCAPCOMPM = COMCOSMKW * (FINSTALC*COMPFGRM + COMPOM)
      ANCAPCOMPH = COMCOSHKW * (FINSTALC*COMPFGRH + COMPOM)
C
C ANCGRCOMPL = LO ANNUALIZED COST OF COMPRESSOR+O&M FOR NON-GRID H2 ($/KG-H2)
C ANCGRCOMPH = HI ANNUALIZED COST OF COMPRESSOR+O&M FOR NON-GRID H2 ($/KG-H2)
C COMPRESEN  = KWH-CONSUMED/KG-H2-COMPRESSED BY COMPRESSOR
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF
C              COMPRESSORS TO H2 PRODUCTION/YR (KG-H2/YR)
C COMPGRTW   = TW OF COMPRESSORS NEEDED OVER SIM FOR GRID H2
C H2PRODGR   = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF ELECTROLYZERS
C              TO H2 PRODUCTION/YR (KG-H2/YR)
C ELYZGRTW   = TW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2
C
      H2KWTOKGPY = COMPGRTW / H2PRODGR
      ANCGRCOMPL = ANCAPCOMPL * H2KWTOKGPY
      ANCGRCOMPM = ANCAPCOMPM * H2KWTOKGPY
      ANCGRCOMPH = ANCAPCOMPH * H2KWTOKGPY
C
C CAPCOMPL  = COMPRESSOR LOW CAPITAL COST ($TRIL)
C CAPCOMPH  = COMPRESSOR HIGH CAPITAL COST ($TRIL)
C COMCOSLKW = LOW HYDROGEN COMPRESSOR COST ($35/KW)
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C COMCOSHKW = HIGH HYDROGEN COMPRESSOR COST ($43/KW)
C COMPKW    = KW OF COMPRESSORS NEEDED FOR NON-GRID H2
C TRILPDOL  = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C
      CAPCOMPL = COMCOSLKW * COMPKW * TRILPDOL
      CAPCOMPM = COMCOSMKW * COMPKW * TRILPDOL
      CAPCOMPH = COMCOSHKW * COMPKW * TRILPDOL
C
C CAPGRCOMPL  = COMPRESSORS FOR GRID H2 LOW CAPITAL COST ($TRIL)
C CAPGRCOMPM  = COMPRESSORS FOR GRID H2 MEAN CAPITAL COST ($TRIL)
C CAPGRCOMPH  = COMPRESSORS FOR GRID H2 HIGH CAPITAL COST ($TRIL)
C COMPGRKW    = KW OF COMPRESSORS NEEDED OVER SIM FOR GRID H2
C
      CAPGRCOMPL = COMCOSLKW * COMPGRKW * TRILPDOL
      CAPGRCOMPM = COMCOSMKW * COMPGRKW * TRILPDOL
      CAPGRCOMPH = COMCOSHKW * COMPGRKW * TRILPDOL
C
C ***************************************************************************
C                     COST OF WATER FOR ELECTROLYSIS
C ***************************************************************************
C ANCOSWATL = LO COST OF WATER FOR MAKING H2 ($/KG-H2) (JACOBSON ETAL SCIENCE 2005)
C ANCOSWATH = HI COST OF WATER FOR MAKING H2 ($/KG-H2) (JACOBSON ETAL SCIENCE 2005)
C
      ANCOSWATL = 0.00472
      ANCOSWATH = 0.00944
      ANCOSWATM = 0.5 * (ANCOSWATL + ANCOSWATH)
C
C ***************************************************************************
C                COST OF DISPENSING H2 FROM STORAGE AND COOLING
C                  THESE APPLY ONLY TO VEHICLES, WHICH REPRESENT
C      91.25 TG-H2/YR OF (91.24+31.70(FOR NH3)+78.72(FOR STEEL))=45% OF TOT
C ***************************************************************************
C H2COSDISL = LO COST ($/KG-H2) DISPENSING H2 FROM STORAGE (NREL, 2014)
C             https://www.nrel.gov/docs/fy14osti/58564.pdf
C H2COSDISM = MEAN COST ($/KG-H2) DISPENSING H2 FROM STORAGE (NREL, 2014)
C H2COSDISH = HI COST ($/KG-H2) DISPENSING H2 FROM STORAGE (NREL, 2014)
C H2CCOOLL  = LO COST ($/KG-H2) COOLING H2 (NREL, 2014)
C             NEEDED AT REFUELING STATIONS TO COOL H2 TO -40C
C             ALSO ELGOWAINY ET AL. (2017) INT J HYD EN 42 (0.5/KG-H2)
C H2CCOOLM  = MN COST ($/KG-H2) COOLING H2 (NREL, 2014)
C H2CCOOLH  = HI COST ($/KG-H2) COOLING H2 (NREL, 2014)
C FRACVEH   = FRACTION OF TOTAL H2 PRODUCED USED FOR VEHICLES
C
      FRACVEH   = 0.45
C
      H2COSDISL = 0.12 * FRACVEH
      H2COSDISM = 0.17 * FRACVEH
      H2COSDISH = 0.21 * FRACVEH
C
      H2CCOOLL  = 0.18 * FRACVEH
      H2CCOOLM  = 0.22 * FRACVEH
      H2CCOOLH  = 0.27 * FRACVEH
C
C ***************************************************************************
C                              H2 STORAGE COST
C ***************************************************************************
C H2STLIFEL = LIFETIME (YEARS) OF H2 STORAGE TANKS GIVING LOW COST
C H2STLIFEM = LIFETIME (YEARS) OF H2 STORAGE TANKS GIVING MEAN COST
C H2STLIFEH = LIFETIME (YEARS) OF H2 STORAGE TANKS GIVING HIGH COST
C             JAMES ET AL. HYDROGEN STORAGE SYSTEM COST ANALYSIS (2016)
C             https://www.osti.gov/servlets/purl/1343975;
C             TABLE 1: 15 YEARS
C
      H2STLIFEL = 20.
      H2STLIFEM = 15.
      H2STLIFEH = 10.
C
C COSTH2TKL = LOW CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C COSTH2TKM = MEAN CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C COSTH2TKH = HI CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C             https://www.hydrogen.energy.gov/pdfs/review22/st235_houchins_2022_p.pdf
C             P.7, FUTRE CASE = $245/KG-H2
C
      COSTH2TKL = 200.
      COSTH2TKM = 250.
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      COSTH2TKH = 300.
C
C H2STOROM  = O&M AS FRACTION OF CAPITAL COST FOR H2 STORAGE
C             PENEV ET AL. (2019) https://www.nrel.gov/docs/fy19osti/73520.pdf AND
C             https://www.hydrogen.energy.gov/pdfs/progress19/ins_sa173_hunter_2019.pdf
C             PENEV ET AL. (2019) https://www.nrel.gov/docs/fy19osti/73520.pdf AND
C             https://www.hydrogen.energy.gov/pdfs/progress19/ins_sa173_hunter_2019.pdf
C             TABLE 1: 1% STORAGE O&M
C
      H2STOROM  = 0.01
C
C CAPSTORL  = STORAGE LOW CAPITAL COST FOR NON-GRID H2  ($TRIL)
C CAPSTORH  = STORAGE HIGH CAPITAL COST FOR NON-GRID H2 ($TRIL)
C COSTH2TKL = LOW CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C COSTH2TKH = HI CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C H2TANK    = MAX STORAGE (TG-H2) THAT H2 TANKS FOR NON-GRID H2 CAN HOLD AT GIVEN TIME
C AKWPTW    = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KG PER TG
C TRILPDOL  = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C
      CAPSTORL = COSTH2TKL * H2TANK * AKWPTW * TRILPDOL
      CAPSTORM = COSTH2TKM * H2TANK * AKWPTW * TRILPDOL
      CAPSTORH = COSTH2TKH * H2TANK * AKWPTW * TRILPDOL
C
C CAPSTORGRL  = STORAGE LOW CAPITAL COST FOR GRID H2  ($TRIL)
C CAPSTORGRH  = STORAGE HIGH CAPITAL COST FOR GRID H2 ($TRIL)
C H2GRTANK    = MAX STORAGE (TG-H2) THAT H2 TANKS FOR GRID H2 CAN HOLD AT GIVEN TIME
C
      CAPSTORGRL = COSTH2TKL * H2GRTANK * AKWPTW * TRILPDOL
      CAPSTORGRM = COSTH2TKM * H2GRTANK * AKWPTW * TRILPDOL
      CAPSTORGRH = COSTH2TKH * H2GRTANK * AKWPTW * TRILPDOL
C
C H2STFACSL = LO FACTOR (1/YR) TO MULT CAPITAL H2STORAGE COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME H2STLIFEL
C H2STFACSH = HI FACTOR (1/YR) TO MULT CAPITAL H2 STORAGE COST BY TO GET ANNUAL COST
C
      H2STTERML  = (1. + DISCOUNTL)**H2STLIFEL
      H2STTERMM  = (1. + DISCOUNTM)**H2STLIFEM
      H2STTERMH  = (1. + DISCOUNTH)**H2STLIFEH
C
      H2STFACSL = DISCOUNTL * H2STTERML / (H2STTERML - 1.)
      H2STFACSM = DISCOUNTM * H2STTERMM / (H2STTERMM - 1.)
      H2STFACSH = DISCOUNTH * H2STTERMH / (H2STTERMH - 1.)
C
C ANCAPH2STL = LOW AN CAP COST OF GRID OR NON-GRID H2 STORAGE ($/KG-H2-STORED-YR)
C ANCAPH2STH = HIGH AN CAP COST OF GRID OR NON-GRID H2 STORAGE ($/KG-H2-STORED-YR)
C COSTH2TKL  = LOW CAPITAL COST H2 TANK ($/KG-H2-STORAGE CAPAC)
C FINSTALL   = LOW INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C FINSTALH   = HI INSTALLATION FACTOR (COST OF LABOR TO INSTALL)
C H2STFACSL  = LO FACTOR (1/YR) TO MULT CAPITAL H2STORAGE COST BY TO GET ANNUAL COST
C              AT DISCOUNT RATE DISCOUNTL AND LIFETIME H2STLIFEL
C H2STFACSH  = HI FACTOR (1/YR) TO MULT CAPITAL H2 STORAGE COST BY TO GET ANNUAL COST
C H2STOROM   = O&M AS FRACTION OF CAPITAL COST FOR H2 STORAGE
C
      ANCAPH2STL = COSTH2TKL * (FINSTALL*H2STFACSL + H2STOROM)
      ANCAPH2STM = COSTH2TKM * (FINSTALM*H2STFACSM + H2STOROM)
      ANCAPH2STH = COSTH2TKH * (FINSTALH*H2STFACSH + H2STOROM)
C
C ANCOSH2STL = LO ANNUAL COST OF NON-GRID H2 STORAGE + O&M ($/KG-H2-PRODUCED)
C ANCOSH2STH = HI ANNUAL COST OF NON-GRID H2 STORAGE + O&M ($/KG-H2-PRODUCED)
C ANCAPH2STL = LOW ANNUAL CAP COST OF GRID OR NON-GRID H2 STORAGE ($/KG-H2-STORED-YR)
C ANCAPH2STH = HIGH ANNUAL CAP COST OF GRID OR NON-GRID H2 STORAGE ($/KG-H2-STORED-YR)
C H2TANK     = MAX STORAGE (TG-H2) THAT H2 TANKS FOR NON-GRID H2 CAN HOLD AT GIVEN TIME
C H2PRODTOT  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
C            = H2PYNONG WHEN IMERGH2=0 OR 2
C
      ANCOSH2STL = ANCAPH2STL * H2TANK / H2PRODTOT
      ANCOSH2STM = ANCAPH2STM * H2TANK / H2PRODTOT
      ANCOSH2STH = ANCAPH2STH * H2TANK / H2PRODTOT
C
C ANCGRH2STL = LO ANNUAL COST OF GRID H2 STORAGE + O&M ($/KG-H2-PRODUCED)
C ANCGRH2STH = HI ANNUAL COST OF GRID H2 STORAGE + O&M ($/KG-H2-PRODUCED)
C H2GRTANK   = MAX STORAGE (TG-H2) THAT H2 TANKS FOR GRID H2 CAN HOLD AT GIVEN TIME
C H2PRODGR   = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C
      ANCGRH2STL = ANCAPH2STL * H2GRTANK / H2PRODGR
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      ANCGRH2STM = ANCAPH2STM * H2GRTANK / H2PRODGR
      ANCGRH2STH = ANCAPH2STH * H2GRTANK / H2PRODGR
C
C *************************************************************************
C                          FUEL CELL COST
C *************************************************************************
C FCCALIFE  = CALENDAR LIFE OF FUEL CELL (40 YEAR) IN 2035. ASSUME SAME AS ELECTROLYZER
C FCLIFEFL  = FUEL CELL LIFE (YEARS) WHEN OPERATING AT FULL LOAD (11 Y)
C           = 11 Y: TABLE 4 OF  CHADLY ET AL. ENERGY 247, 123466 (2022)
C
      FCCALIFE  = 40.
      FCLIFEFL  = 11.
C
C FCELLIFE  = LIFETIME (YR) OF FUEL CELL CORRESPONDING TO USE FACTOR H2UFFCELL
C             IF USE FACTOR DECREASES, LIFETIME LONGER (UP TO LIMIT
C             FCCALIFE), AND O&M COSTS LOWER.
C H2UFFCELL = AVERAGE USE FACTOR (FRACTION OF FUEL CELL FOR PRODUCING
C             ELECTRICITY FOR GRID FROM STORED OR INSTANT H2
C
      FCELLIFE  = MIN(FCLIFEFL / H2UFFCELL, FCCALIFE)
C
C COMPFACSL = LO FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C             AT DISCOUNT RATE DISCOUNTL AND LIFETIME COMPLIFEL
C COMPFACSH = HI FACTOR (1/YR) TO MULT CAPITAL COMPRESSOR COST BY TO GET ANNUAL COST
C
      FCTERML  = (1. + DISCOUNTL)**FCELLIFE
      FCTERMM  = (1. + DISCOUNTM)**FCELLIFE
      FCTERMH  = (1. + DISCOUNTH)**FCELLIFE
C
      H2FCFACSL = DISCOUNTL * FCTERML / (FCTERML - 1.)
      H2FCFACSM = DISCOUNTM * FCTERMM / (FCTERMM - 1.)
      H2FCFACSH = DISCOUNTH * FCTERMH / (FCTERMH - 1.)
C
C H2FCCAPL  = LOW CAPITAL COST ($/KW) OF H2 FUEL CELL
C H2FCCAPM  = MEAN CAPITAL COST ($/KW) OF H2 FUEL CELL
C           = 500/KW FOR   CHADLY ET AL. ENERGY 247, 123466 (2022)
C H2FCCAPH  = HIGH CAPITAL COST ($/KW) OF H2 FUEL CELL
C
      H2FCCAPL     = 400.
      H2FCCAPM     = 500.
      H2FCCAPH     = 600.
C SENSITIVITY TEST IMERGH2=2 CHINA
C     H2FCCAPL     = 150.
C     H2FCCAPM     = 200.
C     H2FCCAPH     = 250.
C
C FINSTALF = FUEL CELL INSTALLATION FACTOR (FACTOR TO MULTIPLY CAP COST
C            BY TO ACCOUNT FOR LABOR)
C          = 1.33 CHADLY ET AL. ENERGY 247, 123466 (2022)
C H2FCOM   = O&M AS FRACTION OF CAPITAL COST OF H2 FUEL CELL
C            3.5%/YR CHADLY ET AL. ENERGY 247, 123466 (2022)
C
      FINSTALF     = 1.33
      H2FCOM       = 0.035
C
C ANCAPFCL = LOW  ANNUAL CAP + O&M COST OF H2 FUEL CELLS FOR GRID H2 ($/KW-YR)
C ANCAPFCM = MEAN ANNUAL CAP + O&M COST OF H2 FUEL CELLS FOR GRID H2 ($/KW-YR)
C ANCAPFCH = HIGH ANNUAL CAP + O&M COST OF H2 FUEL CELLS FOR GRID H2 ($/KW-YR)
C
      ANCAPFCL = H2FCCAPL * (FINSTALF*H2FCFACSL + H2FCOM)
      ANCAPFCM = H2FCCAPM * (FINSTALF*H2FCFACSM + H2FCOM)
      ANCAPFCH = H2FCCAPH * (FINSTALF*H2FCFACSH + H2FCOM)
C
C ANCGRFCL   = LO ANNUALIZED COST OF FUEL CELL+O&M FOR GRID H2 ($/KG-H2)
C ANCGRFCH   = HI ANNUALIZED COST OF FUEL CELL+O&M FOR GRID H2 ($/KG-H2)
C H2KWTOKGPY = RATIO OF NAMEPLATE CAPACITY (KW) OF FUEL CELLS TO
C              PRODUCTION/YR (KG-H2/YR)
C FCCHARG    = MAX CHARGE RATE (TW) OF GRID H2 STORAGE THRU ELECTROLYZERS/COMPRESSORS
C              USED WHEN IMERGH2=1,2,3 BUT NOT 0. WHEN IMERGH2=1,3,
C              FCCHARG IS REPLACED BY H2PEAKLD
C FCDISCH    = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C            = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C              MULTIPLIED BY H2DCEFF * H2CHAREFF
C H2PRODGR   = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C H2PRODTOT  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
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```
C            = H2PYNONG WHEN IMERGH2=0 OR 2
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       H2KWTOKGPY = FCDISCH / H2PRODTOT
      ELSEIF (IMERGH2.EQ.2) THEN
       H2KWTOKGPY = FCDISCH / H2PRODGR
      ELSE
       H2KWTOKGPY = 0.
      ENDIF
C
      ANCGRFCL   = ANCAPFCL * H2KWTOKGPY
      ANCGRFCM   = ANCAPFCM * H2KWTOKGPY
      ANCGRFCH   = ANCAPFCH * H2KWTOKGPY
C
C CAPFCL   = H2 FUEL CELL FOR GRID ELEC LOW CAPITAL COST ($TRIL)
C CAPFCH   = H2 FUEL CELL FOR GRID ELEC HIGH CAPITAL COST ($TRIL)
C H2FCCAPL = LOW CAPITAL COST ($/KW) OF H2 FUEL CELL
C H2FCCAPH = HIGH CAPITAL COST ($/KW) OF H2 FUEL CELL
C TRILPDOL = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C FCDISCH  = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C          = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C            MULTIPLIED BY H2DCEFF * H2CHAREFF
C AKWPTW   = 1.0E+09  KILOWATTS (KW) PER TERAWATT (TW) OR KWH PER TWH
C
      FCONVX = FCDISCH * AKWPTW * TRILPDOL
      CAPFCL = H2FCCAPL * FCONVX
      CAPFCM = H2FCCAPM * FCONVX
      CAPFCH = H2FCCAPH * FCONVX
C
C ***************************************************************************
C SUM NON-GRID H2 COSTS FOR ELECTROLYSIS, WATER, COMPRESSION, DISPENSING ,STORAGE
C ***************************************************************************
C COSH2KGL   = LO COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C              DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C COSH2KGM   = MN COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C COSH2KGH   = HI COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C ANCOSELYZL = LO ANNUALIZED COST OF ELECTROLYZER + O&M ($/KG-H2)
C ANCOSELYZH = HI ANNUALIZED COST OF ELECTROLYZER + O&M ($/KG-H2)
C ANCOSWATL  = LO ANNUAL COST OF WATER ($/KG-H2)
C ANCOSWATH  = HI ANNUAL COST OF WATER ($/KG-H2)
C ANCOSCOMPL = LO ANNUALIZED COST OF COMPRESSOR + O&M ($/KG-H2)
C ANCOSCOMPH = HI ANNUALIZED COST OF COMPRESSOR + O&M ($/KG-H2)
C ANCOSH2STL = LO ANNUAL COST OF H2 STORAGE + O&M ($/KG-H2)
C ANCOSH2STH = HI ANNUAL COST OF H2 STORAGE + O&M ($/KG-H2)
C H2COSDISL  = LO COST ($/KG-H2) DISPENSING H2 FROM STORAGE (NREL, 2014)
C H2COSDISH  = HI COST ($/KG-H2) DISPENSING H2 FROM STORAGE (NREL, 2014)
C H2CCOOLL   = LO COST ($/KG-H2) COOLING H2 (NREL, 2014)
C H2CCOOLH   = HI COST ($/KG-H2) COOLING H2 (NREL, 2014)
C
C NEW
C          = 0.629  - 2.14   $/KG-H2 TOTAL
C          = 0.195  - 0.918  $/KG-H2 FOR ELECTROLYZER
C          = 0.148  - 0.596  $/KG-H2 FOR COMPRESSOR
C          = 0.281  - 0.612  $/KG-H2 FOR STORAGE (W/ DAYH2STOR=5)
C          = 0.0047 - 0.0094 $/KG-H2 FOR WATER
C
      COSH2KGL = ANCOSELYZL + ANCOSWATL + ANCOSCOMPL + ANCOSH2STL
     1         + H2COSDISL  + H2CCOOLL
      COSH2KGM = ANCOSELYZM + ANCOSWATM + ANCOSCOMPM + ANCOSH2STM
     1         + H2COSDISM  + H2CCOOLM
      COSH2KGH = ANCOSELYZH + ANCOSWATH + ANCOSCOMPH + ANCOSH2STH
     1         + H2COSDISH  + H2CCOOLH
C
C ***************************************************************************
C SUM GRID H2 COSTS FOR ELECTROLYSIS, COMPRESSION, WATER, STORAGE, FUEL CELL
C ***************************************************************************
C CGRH2KGL   = LO COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C              FOR GRID H2 DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C              IT IS NOT FOR NON-GRID H2
C CGRH2KGH   = HIGH COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C ANCGRELYZL = LO ANNUALIZED COST OF ELECTROLYZER + O&M FOR GRID H2 ($/KG-H2)
C ANCOSWATL  = LO ANNUAL COST OF WATER ($/KG-H2)
C ANCGRCOMPL = LO ANNUALIZED COST OF COMPRESSOR + O&M FOR GRID H2 ($/KG-H2)
C ANCGRH2STL = LO ANNUAL COST OF H2 STORAGE + O&M FOR GRID H2 ($/KG-H2)
C ANCGRFCL   = LO ANNUALIZED COST OF FUEL CELL+O&M FOR GRID H2 ($/KG-H2)
```

```
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       CGRH2KGL = ANCGRFCL
       CGRH2KGM = ANCGRFCM
       CGRH2KGH = ANCGRFCH
      ELSEIF (IMERGH2.EQ.2) THEN
       CGRH2KGL = ANCGRELYZL + ANCOSWATL + ANCGRCOMPL + ANCGRH2STL
     1          + ANCGRFCL
       CGRH2KGM = ANCGRELYZM + ANCOSWATM + ANCGRCOMPM + ANCGRH2STM
     1          + ANCGRFCM
       CGRH2KGH = ANCGRELYZH + ANCOSWATH + ANCGRCOMPH + ANCGRH2STH
     1          + ANCGRFCH
      ELSE
       CGRH2KGL = 0.
       CGRH2KGM = 0.
       CGRH2KGH = 0.
      ENDIF
C
C ***************************************************************************
C                   PRINT OUT ENERGY BUDGET
C ***************************************************************************
C TWHDEMAND = TWH OF ELECTRIC POWER INFLEX+FLEXIBLE LOAD DURING SIMULATION.
C             THIS DOES NOT INCLUDE TWHSTORH2, TWHSHEAT, TWHSCOLD OR TWHSHIGHT
C             BUT INCLUDES TWHELECH2, TWHEHEAT, TWHECOLD, TWHEHIGHT
C ALLLOSSES = TWH OF ALL ENERGY LOST IN/OUT STORAGE OR FROM T&D OR CURTAILMENT
C CHANGSTOR = TWH LOSS (+) OR GAIN (-) IN ALL STORAGE BETWEEN BEGIN&END OF SIM
C           = CHANGCOLD + CHANUGS
C
      WRITE(IOUT,266) ENDLOAD,TSUMLOAD,TSUMFLXLD,TSUMH2LD,
     1                TWHDEMAND + TWHSTORH2,
     1                TWHSHEAT,TWHSCOLD,TWHSHIGHT,
     1                ALLELECHT,ELECOTH,ALLELECH2,
     1                TWHSHEAT  + TWHEHEAT,
     1                TWHSCOLD  + TWHECOLD,
     1                TWHSHIGHT + TWHEHIGHT,
     1                ALLLOSSES,TSUMTDLS,
     1                TSUMCSTLS,TSUMCSTLI,OUTLSCSP,
     1                TSUMPSTLS,TSUMPSTLI,OUTLSPHS,
     1                TSUMBSTLS,TSUMBSTLI,OUTLSBAT,
     1                TSUMFSTLS,TSUMFSTLI,OUTLSH2E,
     1                TSUMOSTLS,TSUMOSTLI,OUTLCOLD,
     1                TSUMHSTLS,TSUMHSTLI,OUTLWARM,
     1                TSUMUGSTL,TSUMUGSTI,OUTLSUGS,
     1                TSUMBRSTL,TSUMBRSTI,OUTLSBRS,
     1                TSUMSHED,ALLENERGY,
     1                PERCLOSS,TSUPORIG,TSUMWIND,TSUMSOL,TSUMHYD,
     1                TSUMWAV,TSUMGEO,TSUMTID,TSUMSHT,TSUMGHT,
     1                CHANGSTOR,CHANGCSPS,CHANGPHSS,CHANGBATS,
     1                CHANGHELS,CHANGCOLD,CHANGWARM,CHANGUTES,
     1                CHANGBRCK,CHANGH2S,ALLPROD,H2ALLUSED,TSUMHRS

 266  FORMAT(
     1   'TWH END-USE TOTAL LOAD  MET DURING SIM      ',18X,0PF13.5,/
     1   'TWH END USE INFLEXIBLE LOAD                 ',9X,0PF13.5,/
     1   'TWH END USE FLEXIBLE LOAD OR MET BY STORAGE ',9X,0PF13.5,/
     1   'TWH END USE LOAD MET BY STORED H2+CUR ELEC  ',9X,0PF13.5,/
     1   'TWH END USE ELECTRICITY LOAD MET DURING SIM ',0PF13.5,/
     1   'TWH END USE HEAT LOAD MET BY STORAGE        ',0PF13.5,/
     1   'TWH END USE COLD LOAD MET BY STORAGE        ',0PF13.5,/
     1   'TWH END USE HI-T LOAD MET BY BRICK STORAGE  ',0PF13.5,/
     1   'TWH ALL ELEC+HEAT DURING SIMULATION         ',18X,0PF13.5,/
     1   'TWH ELECTRICITY NOT FOR H2 DURING SIM       ',9X,0PF13.5,/
     1   'TWH ELECTRICITY FOR H2 DURING SIMULATION    ',9X,0PF13.5,/
     1   'TWH ENERGY FOR HEAT FROM ELEC + STORAGE     ',9X,0PF13.5,/
     1   'TWH ENERGY FOR COLD FROM ELEC + STORAGE     ',9X,0PF13.5,/
     1   'TWH ENERGY FOR HI-T FROM ELEC + STORAGE     ',9X,0PF13.5,/
     1   'TWH TOTAL LOSSES DURING SIMULATION          ',18X,0PF13.5,/
     1   'TWH TRANSMISSION AND DISTRIBUTION LOSSES    ',9X,0PF13.5,/
     1   'TWH LOSSES CHARG+DISCHARGING CSP STORAGE    ',9X,0PF13.5,/
     1   'TWH LOSSES DURING CHARGING CSP STORAGE      ',0PF13.5,/
     1   'TWH LOSSES DURING DISCHARGING CSP STORAGE   ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCHARGING PHS STORAGE    ',9X,0PF13.5,/
     1   'TWH LOSSES DURING CHARGING PHS STORAGE      ',0PF13.5,/
     1   'TWH LOSSES DURING DISCHARGING PHS STORAGE   ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCH BATTERY STORAGE      ',9X,0PF13.5,/
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     1   'TWH LOSSES CHARGING BATTERY STORAGE         ',0PF13.5,/
     1   'TWH LOSSES DISCHARG BATTERY STORAGE         ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCH H2 ELEC STORAGE      ',9X,0PF13.5,/
     1   'TWH LOSSES CHARGING H2 ELEC STORAGE         ',0PF13.5,/
     1   'TWH LOSSES DISCHARG H2 ELEC STORAGE         ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCH CW-STES+PCM-ICE STOR ',9X,0PF13.5,/
     1   'TWH LOSSES CHARGING CW-STES+PCM-ICE STORAGE ',0PF13.5,/
     1   'TWH LOSSES DISCHARG CW-STES+PCM-ICE STORAGE ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCH HW-STES STORAGE      ',9X,0PF13.5,/
     1   'TWH LOSSES CHARGING HW-STES STORAGE         ',0PF13.5,/
     1   'TWH LOSSES DISCHARG HW-STES STORAGE         ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCHARGING UTES STORAGE   ',9X,0PF13.5,/
     1   'TWH LOSSES DURING CHARGING UTES STORAGE     ',0PF13.5,/
     1   'TWH LOSSES DURING DISCHARGING UTES STORAGE  ',0PF13.5,/
     1   'TWH LOSSES CHARG+DISCHARGING BRICK HT STOR  ',9X,0PF13.5,/
     1   'TWH LOSSES DURING CHARGING BRICK HT STOR    ',0PF13.5,/
     1   'TWH LOSSES DURING DISCHARGING BRICK HT STOR ',0PF13.5,/
     1   'TWH LOSSES FROM CURTAILMENT                 ',9X,0PF13.5,/
     1   'TWH TOTAL END-USE LOAD PLUS LOSSES          ',18X,0PF13.5,/
     1   'PERCENT OF TOTAL LOAD+LOSS THAT IS LOSS     ',0PF13.5,/
     1   'TWH TOTAL ENERGY SUPPLY BEFORE T&D LOSSES   ',18X,0PF13.5,/
     1   'TWH ON+OFFSHORE WIND SUPPLY BEFORE T&D LOSS ',0PF13.5,/
     1   'TWH PV+CSP SUPPLY BEFORE T&D LOSS           ',0PF13.5,/
     1   'TWH HYDROELECTRIC SUPPLY BEFORE T&D LOSS    ',0PF13.5,/
     1   'TWH WAVE SUPPLY BEFORE T&D LOSS             ',0PF13.5,/
     1   'TWH GEOTHERMAL ELEC SUPPLY BEFORE T&D LOSS  ',0PF13.5,/
     1   'TWH TIDAL SUPPLY BEFORE T&D LOSS            ',0PF13.5,/
     1   'TWH SOL HOT FLUID SUPPLY BEFORE T&D LOSS    ',0PF13.5,/
     1   'TWH GEOTHERMAL HEAT SUPPLY BEFORE T&D LOSS  ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) ALL STORAGE    ',18X,0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) CSP STORAGE    ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) PHS STORAGE    ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) BAT STORAGE    ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) H2 ELEC STOR   ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) CW-STES+PCMICE ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) HW-STES STOR   ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) UTES STORAGE   ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) BRICK STORAGE  ',0PF13.5,/
     1   'TWH USED FROM(+) ADDED TO(-) H2 STORAGE     ',0PF13.5,/
     1   'TWH SUPPLIED+TAKEN FROM OR ADDED TO STORAGE ',18X,0PF13.5,/
     1   'TG-H2 USED DURING SIMULATION                ',0PF13.5,/
     1   'NUMBER OF HOURS OF SIMULATION               ',0PF13.5/)

C STORCINIT = INITIAL ENERGY AVAILABLE IN CSP STORAGE (TWH)
C STORPINIT = INITIAL ENERGY AVAILABLE IN PHS STORAGE (TWH)
C STORBINIT = INITIAL ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C STORFINIT = INITIAL ENERGY AVAILABLE IN H2 ELECRICITY STORAGE (TWH)
C STOROINIT = INITIAL ENERGY AVAILABLE IN CW-STES+PCM-ICE STORAGE (TWH)
C STORHINIT = INITIAL ENERGY AVAILABLE IN HW-STES STORAGE (TWH)
C UGSTINIT  = INITIAL ENERGY AVAILABLE IN UNDERGROUND UTES STORAGE (TWH)
C             REALLY EQUIVALENT ELECTRICITY THAT GIVES NEEDED HEAT
C             WITH HEAT PUMPS OF COP=CPERFORM
C STORCCUR  = CURRENT ENERGY AVAILABLE IN CSP STORAGE (TWH)
C STORPCUR  = CURRENT ENERGY AVAILABLE IN PHS STORAGE (TWH)
C STORBCUR  = CURRENT ENERGY AVAILABLE IN BATTERY STORAGE (TWH)
C STORFCUR  = CURRENT ENERGY AVAILABLE IN H2 ELECTRICITY STORAGE (TWH)
C STOROCUR  = CURRENT ENERGY AVAILABLE IN CW-STES+PCM-ICE STORAGE (TWH)
C STORHCUR  = CURRENT ENERGY AVAILABLE IN HW-STES STORAGE (TWH)
C UGSTORCUR = CURRENT ENERGY IN UNDERGROUND SOIL OR WATER STORAGE (TWH)
C             REALLY CURRENT TWH OF ELECTRICITY STORED IN UTES THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C HYDROINIT = INIT HYDRO ENERGY (TWH) STORED IN RESERVOIRS BEFORE T&D LOSS
C PEAKHYD   = 2050 HYDROPOWER AFTER T&D LOSSES DELIVERED USED FOR PEAKING POWER (TW)
C HYDTWHMAX = MAX TWH ENERGY THAT CAN BE STORED IN ALL HYDRO RESERVOIRS
C             FOR PEAKING+BASELOAD FROM HYDRO TURBINE BEF T&D IN REGION AT GIVEN MOMENT
C PKHYDMAX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR PEAKING BEF T&D ACCOUNTED FOR
C BASHYDMX  = 2050 MAX HYDRO STORAGE CAPACITY (TWH) FOR BASELOAD BEF T&D ACCOUNTED FOR
C
      WRITE(IOUT,263) STORCINIT,  TSUMCSTOR, STORCCUR,
     1                STORCINIT + TSUMCSTOR
      WRITE(IOUT,264) STORPINIT,  TSUMPSTOR, STORPCUR,
     1                STORPINIT + TSUMPSTOR
      WRITE(IOUT,267) STORBINIT,  TSUMBSTOR, STORBCUR,
     1                STORBINIT + TSUMBSTOR
      WRITE(IOUT,270) STORFINIT,  TSUMFSTOR, STORFCUR,
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     1               STORFINIT + TSUMFSTOR
      WRITE(IOUT,273) STOROINIT,  TSUMOSTOR, STOROCUR,
     1                STOROINIT + TSUMOSTOR
      WRITE(IOUT,274) STORHINIT,  TSUMHSTOR, STORHCUR,
     1                STORHINIT + TSUMHSTOR
      WRITE(IOUT,275) UGSTINIT,   TSUMUGSTO, UGSTORCUR,
     1                UGSTINIT  + TSUMUGSTO
      WRITE(IOUT,588) BRICKINIT,  TSUMBRSTO, BRSTORCUR,
     1                BRICKINIT + TSUMBRSTO
      WRITE(IOUT,276) H2STINIT,   TSUMH2STO, H2CURSTOR,
     1                H2STINIT  + TSUMH2STO
      WRITE(IOUT,277) HYDROINIT, HYDROTWH, PKHYDMAX, HYDTWHMAX
C
C ANYREMAIN = SUM OF REMAINHR (TWH) AT END OF SIM OVER ALL SIMULATION
C             HOURS. ANYREMAIN SHOULD EQUAL REMAINDEM AT ALL TIMES
C
      ANYREMAIN  = 0.
      DO I       = 1, MXHRSIM
       ANYREMAIN = ANYREMAIN + REMAINHR(I)
      ENDDO
C
      WRITE(IOUT,265) TSUMLOAD+TSUMFLXLD+TSUMH2LD+REMAINDEM,
     1                TSUMLOAD,TSUMFLXLD,TSUMH2LD,REMAINDEM,
     1                TLOADALL,TLOADFLX,TLOADALL-TLOADFLX,
     1                ANYREMAIN
C
C H2LDMEAN  = MEAN NON-GRID H2 LOAD (TW) OVER ENTIRE SIM = TLOADH2 WHEN IMERGH2=0 OR 2
C           = MEAN GRID+NON-GRID H2 LOAD(TW) OVER SIM WHEN IMERGH2=1,3
C             LOAD USED TO FOR ELECTROLYZERS/COMPRESSORS
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR NON-GRID H2 ELECTROLYSIS+COMPRES OVER SIM
C H2USEFACI = INSTANTANEOUS NON-GRID H2 USE FACTOR (INSTANT PEAK LOAD / MEAN LOAD)
C             IF USE FACTOR LESS, LIFETIME (ELYZLIFE, COMPLIFE) SHOULD BE
C             LONGER, O&M (ELYZOM, COMPOM) LOWER
C H2LDMELEC = MEAN POWER (TW) OVER ENTIRE SIM, USED TO PRODUCE H2 FOR
C             ELEC STORAGE BY ELECTROLYZERS/COMPRESSORS
C FCCHARG   = MAX CHARGE RATE (TW) OF H2 GRID ELEC STORAGE THROUGH
C             ELECTROLYZERS/COMPRESSORS
C H2UFGRID  = AVERAGE USE FACTOR (FRACTION )OF ELECTROLYZERS/COMPRESSORS
C             FOR PRODUCING H2 FOR GRID ELECTRICITY
C H2LDFCELL = MEAN POWER (TW) OVER ENTIRE SIM AND AFTER TLOSSES,
C             DISCHARGED FROM FUEL CELLS FOR GRID ELECTRICITY USE.
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C H2UFFCELL = AVERAGE USE FACTOR (FRACTION OF FUEL CELL FOR PRODUCING
C             ELECTRICITY FOR GRID FROM STORED OR INSTANT H2
C
      WRITE(IOUT,278) H2LDMEAN,  H2LDPEAKI, H2USEFACI,
     1                H2LDMELEC, FCCHARG,   H2UFGRID,
     1                H2LDFCELL, FCDISCH,   H2UFFCELL
C
 278  FORMAT(
     1   'TW AVG LOAD FOR NON-GRID H2 OVER SIMULATION  ',18X,0PF13.5,/
     1   'TW INSTANT PEAK LOAD FOR NON-GRID H2 OVER SIM',18X,0PF13.5,/
     1   'USEFAC ELYZR FOR NON-GRID H2 (MEAN/INST PEAK)',18X,0PF13.5,//
     1   'TW AVG ELEC LOAD FOR GRID H2 OVER SIMULATION ',18X,0PF13.5,/
     1   'TW INSTANT PEAK LOAD FOR GRID H2 OVER SIM    ',18X,0PF13.5,/
     1   'USEFAC ELYZER FOR GRID H2 (MEAN/PEAK LOAD)   ',18X,0PF13.5,//
     1   'TW AV LOAD TO GRID FROM FUEL CELLS OVER SIM  ',18X,0PF13.5,/
     1   'TW INSTANT PEAK LOAD FROM FUEL CELLS OVER SIM',18X,0PF13.5,/
     1   'USEFAC FUEL CELLS FOR GRID (MEAN/INST PEAK)  ',18X,0PF13.5,/)
C
C H2PRODGR  = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELEC STORAGE
C H2TANK    = MAX STORAGE (TG-H2) H2 TANKS FOR NON-GRID H2 CAN HOLD
C H2GRTANK  = MAX STORAGE (TG-H2) H2 TANKS FOR GRID H2 CAN HOLD
C ELYZGRTW  = TW OF ELECTROLYZERS NEEDED OVER SIM FOR GRID H2
C ELYZLIFGR = LIFETIME (YR) OF ELECTROLYZER CORRESPONDING TO USE FACTOR H2UFGRID,
C             THUS FOR PRODUCING H2 FOR GRID ELECTRICITY STORAGE
C COMPLIFGR = LIFETIME (YR) OF COMPRESSOR CORRESPONDING TO USE FACTOR H2UFGRID,
C             THUS FOR PRODUCING H2 FOR GRID ELECTRICITY STORAGE
C
      WRITE(IOUT,256) H2ENERGY,
     1                TGH2PYR,
     1                H2PRODGR,
     1                H2TANK,
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     1               H2GRTANK,
     1               FRCH2STOR,
     1               ELYZTW,
     1               ELYZGRTW,
     1               COMPTW,
     1               COMPGRTW,
     1               ELYZCOSL,   ELYZCOSM,  ELYZCOSH,
     1               RECTCOSL,   RECTCOSM,  RECTCOSH,
     1               COMCOSLKW,  COMCOSMKW, COMCOSHKW,
     1               COSTH2TKL,  COSTH2TKM, COSTH2TKH,
     1               H2FCCAPL,   H2FCCAPM,  H2FCCAPH,
     1               ELYZLIFE,   ELIFEYFL,  ECALLIFE, ELYZLIFGR,
     1               COMPLIFE,   CLIFEYFL,  CCALLIFE, COMPLIFGR,
     1               H2STLIFEL,  H2STLIFEM, H2STLIFEH,
     1               FCELLIFE,   FCLIFEFL,  FCCALIFE,
     1               ELYZOM,     RECTOM,    COMPOM, H2STOROM, H2FCOM
C
 256  FORMAT('H2ENERGY(KWH/KGH2 ELEC+COMP)        = ',1(1X,0PF12.5),/
     1       'TGH2PYR (TG-NON-GRID H2/YR) PROD    = ',1(1X,0PF12.5),/
     1       'H2PRODGR (TG-GRID H2/YR) PROD       = ',1(1X,0PF12.5),/
     1       'H2TANK (TG-H2 TANK SIZE-NONGRID H2) = ',1(1X,0PF12.5),/
     1       'H2GRTANK (TG-H2 TANK SIZE-GRID H2)  = ',1(1X,0PF12.5),/
     1       'FRCH2STOR (TG-H2TANK/TG-H2-PROD/YR) = ',1(1X,0PF12.5),/
     1       'ELYZTW (TW-NON-GRID ELECTLYZER SIZE)= ',1(1X,0PF12.5),/
     1       'ELYZGRTW (TW-GRID ELECTLYZER SIZE)  = ',1(1X,0PF12.5),/
     1       'COMPTW (TW-NON-GRID-COMPRESSOR SIZE)= ',1(1X,0PF12.5),/
     1       'COMPGRTW (TW-GRID-COMPRESSOR SIZE)  = ',1(1X,0PF12.5),/
     1       'ELYZCOS  (LO MN HI $/KW ELECTLYZER) = ',3(1X,0PF12.5),/
     1       'RECTCOS  (LO MN HI $/KW RECTIFIER)  = ',3(1X,0PF12.5),/
     1       'COMCOSKW (LO MN HI $/KW COMPRESSOR) = ',3(1X,0PF12.5),/
     1       'COSTH2TK (LO MN HI H2 TANK $/KG-H2) = ',3(1X,0PF12.5),/
     1       'H2FCCAPM (LO MN HI FUELCELL $/KW-FC)= ',3(1X,0PF12.5),/
     1       'ELYZLIFE (NONGRID FULOAD CAL GRID-YR)=',4(1X,0PF12.5),/
     1       'COMPLIFE (NONGRID FULOAD CAL GRID-YR)=',4(1X,0PF12.5),/
     1       'H2STLIFE (LO MN HI LIFE H2STOR-YR)  = ',3(1X,0PF12.5),/
     1       'FCELLIFE (ACTUAL FULL-LOAD CAL YR)  = ',3(1X,0PF12.5),/
     1       'O&M (ELYZ REC COMP STOR FC O&M-FRAC)= ',5(1X,0PF12.5),/)
C
C FACSHT    = FACTOR TO MULTIPLY DELIVERED SOLAR PV+CSP BY TO ESIMATE SOLAR
C             HEAT FROM ROOF OR UTILITY HEAT COLLECTORS (E.G., WATER, GLYCOL)
C SUPPMAX   = MAX TW OF WIND+SOLAR ELECTRIC POWER SUPPLIED ANY TIME DURING YEAR
C TWHONWIN  = CUMULATIVE TWH ONSHORE WIND PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHOFFWIN = CUMULATIVE TWH OFFSHORE WIND PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHROOFPV = CUMULATIVE TWH ROOF PV PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHUTILPV = CUMULATIVE TWH UTILITY PV PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHCSP    = CUMULATIVE TWH UTILITY CSP PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHSTCSP  = CUMULATIVE TWH OF CSP THAT GOES STRAIGHT TO STORAGE (AFTER T&D LOSS)
C TWHHYD    = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHPKHYD  = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHBSHYD  = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHWAV    = CUMULATIVE TWH WAVE PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHGEOEL  = CUMULATIVE TWH GEOTHERMAL ELEC PROD DURING SIM (AFTER T&D LOSSES)
C TWHTID    = CUMULATIVE TWH TIDAL PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHTHEAT  = CUMULATIVE TWH SOLAR THERMAL HEAT PROD DURING SIM (AFTER T&D LOSSES)
C TWHGEOHT  = CUMULATIVE TWH GEOTHERMAL HEAT PROD DURING SIM (AFTER T&D LOSSES)
C HRSSIM    = NUMBER OF HOURS OF SIMULATION (HOURS)
C TDEFFMN   = 1-TDLOSMN = TRANSMIS+DISTRIB EFFIC AS FRACTION OF POWER TRANSMITTED
C TOTONWND  = TOTAL NEW+EXISTING INSTALLED ONSHORE WIND CAPACITY (TW)
C TOTOFFWND = TOTAL NEW+EXISTING INSTALLED OFFSHORE WIND CAPACITY (TW)
C TOTROOFPV = TOTAL NEW+EXISTING INSTALLED RES + COMM/GOV ROOF PV CAPACITY (TW)
C TOTUTILPV = TOTAL NEW+EXISTING INSTALLED UTILITY SCALE PV CAPACITY (TW)
C TOTCSP    = TOTAL NEW+EXISTING INSTALLED CSP INSTALLED CAPACITY (TW)
C TOTHYDRO  = TOTAL NEW+EXISTING INSTALLED HYDROELECTRIC CAPACITY (TW)
C           = HYDISCHTW = PEAK DISCHARGE RATE OF HYDRO (TW). INCLUDES ANY
C             HYDRO TURBINES ADDED TO INCREASE PEAK DISCHARGE RATE.
C TOTWAVE   = TOTAL NEW+EXISTING INSTALLED WAVE CAPACITY (TW)
C TOTGEOEL  = TOTAL NEW+EXISTING INSTALLED GEOTHERMAL ELEC POWER CAPACITY (TW)
C TOTTID    = TOTAL NEW+EXISTING INSTALLED TIDAL CAPACITY (TW)
C TOTSHEAT  = TOTAL NEW+EXISTING SOLAR THERMAL INSTALLED CAPACITY (TW)
C TOTGHEAT  = TOTAL NEW+EXISTING GEOTHERMAL HEAT INSTALLED CAPACITY (TW)
C CURGEO    = 2050 CONUS GEOTHERMAL DELIVERED POWER (TW) (NOT NAMEPLATE CAPACITY)
C CURHYD    = 2050 REGIONAL BASE+PEAK HYDRO DELIVERED POWER AFTER T&D LOSSES (TW)
C TURBHYD   = 2050 ANNUAL AVG BASE+PEAK HYDRO RELEASED FROM TURBINE (TW) BEF T&D LOSSES
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR BASELOAD+PEAKING (TW) BEF T&D
C BASEHYD   = 2050 HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR BASELOAD POWER (TW)
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C           = CONSTANT CHARGE AND DISCHARGE RATE (TW) OF HYDRO FOR BASELOAD
C PEAKHYD   = 2050 ANN-AVG HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR PEAKING POWER (TW)
C           = ANNUAL-AVERAGE CHARGE RATE OF HYDRO FOR PEAKING (TW) BEF T&D
C             BASEHYD, PEAKHYD, AND TURBHYD ARE ALL BEFORE T&D LOSSES
C CURTID    = 2050 REGIONAL ANNUAL AVERAGE TIDAL DELIVERED POWER (TW)
C CURWAV    = 2050 REGIONAL ANNUAL AVERAGE  WAVE DELIVERED POWER (TW)
C HRSSIM    = NUMBER OF HOURS OF SIMULATION (HOURS)
C TWHSHEAT  = TOTAL LOAD (TWH) MET BY HEAT STORAGE (HW-STES+UTES) DURING SIM
C           = SUM OF FLEXHEAT OVER SIMULATION
C             REMAINING HEAT LOAD IS MET BY ELECTRICITY
C TWHSCOLD  = TOTAL LOAD (TWH) MET BY COLD STORAGE (CW-STES+PCM-ICE) DURING SIM
C           = SUM OF FLEXCOLD OVER SIMULATION
C             REMAINING COLD LOAD IS MET BY ELECTRICITY
C TWHSHIGHT = TOTAL LOAD (TWH) MET BY HI-T BRICK STORAGE DURING SIM
C           = SUM OF HITFROMST OVER SIMULATION
C             REMAINING HI-T LOAD IS MET BY ELECTRICITY
C TWHSTORH2 = TWH OF H2 LOAD MET BY H2 PREVIOUSLY IN STORAGE
C TWHDEMAND = TWH OF ELECTRIC POWER INFLEX+FLEXIBLE LOAD DURING SIMULATION.
C             THIS DOES NOT INCLUDE TWHSTORH2, TWHSHEAT, TWHSCOLD OR TWHSHIGHT
C             BUT INCLUDES TWHELECH2, TWHEHEAT, TWHECOLD, TWHEHIGHT
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C UTESTWH   = INSTALLED TWH UNDERGROUND SEAS HEAT STORAGE IN SOIL OR WATER
C             REALLY TWH OF ELECTRICITY STORAGE THAT GIVES NECESSARY
C             HEATING FROM HEAT PUMPS WITH COP=CPERFORM
C STORUGHRS = HOURS OF UNDERGROUND SEAS HEAT STORAGE IN SOIL OR WATER (UTES) (HRS)
C MXHRDRM   = MAX NUMBER OF HOURS FORWARD THAT LOAD CAN BE SHIFTED BY
C             DEMAND-RESPONSE MANAGEMENT
C TWHH2TOT  = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C CHARGTW   = MAXIMUM RATE OF CHARGING NON-UTES STORAGE (TW)
C             THIS IS GREATER THAN RATE OF DISCHARGING SINCE CSP COLLECTORS
C             ARE OVERSIZED RELATIVE TO STEAM TURBINE.
C             CHARGING AND DISCHARGING RATES ARE THE SAME FOR OTHERS.
C
      WRITE(IOUT,254) TWHDEMAND, TWHSHEAT, TWHSCOLD,TWHSHIGHT,TWHSTORH2,
     1                TWHDEMAND +TWHSHEAT +TWHSCOLD+TWHSHIGHT+TWHSTORH2,
     1                ALLLOSSES,TWHSUPPLY,TSUMTDLS,CHANGSTOR,
     1                TWHDEMAND+TWHSHEAT+TWHSCOLD+TWHSHIGHT+TWHSTORH2
     1               +ALLLOSSES-TWHSUPPLY-CHANGSTOR-TSUMTDLS
C
C ***************************************************************************
C     PRINT CAPACITY FACTORS BEFORE TRANSMISSION AND DISTRIBUTION LOSSES
C            (ALSO BEFORE ANY LOSSES TO/FROM STORAGE OR CURTAILMENT)
C ***************************************************************************
C CPERF1 = COEF OF PERFORMANCE OF HEAT PUMPS WHEN NEW SOLAR+GEOTHERMAL
C          HEAT ASSUMED. NEW SOLAR+GEOTHERMAL HEAT ARE ASSUMED TO BE
C          CONVERTED TO ELECTRICITY POWERING HEAT PUMPS
C        = 1 WHEN ONLY EXISTING SOLAR+GEOTHERMAL HEAT ASSUMED SINCE EXISTING
C          SOLAR+GEOTHERMAL HEAT IS TREATED AS HEAT IN IEA DATABASE
C          SO NO NEED TO CONVERT TO EQUIVALENT ELECTRICITY
C
      WRITE(IOUT,255)
     1      TWHONWIN         /(TOTONWND *HRSSIM*TDEFFMN(IONWIND)),
     1      TWHOFFWIN        /(TOTOFFWND*HRSSIM*TDEFFMN(IOFFWIND)),
     1      TWHROOFPV        /(TOTROOFPV*HRSSIM*TDEFFMN(IRESPV)),
     1      TWHUTILPV        /(TOTUTILPV*HRSSIM*TDEFFMN(IUTILPV)),
     1     (TWHCSP+TWHSTCSP) /(TOTCSP   *HRSSIM*TDEFFMN(ICSPSTOR)),
     1      TWHGEOEL         /(TOTGEOEL *HRSSIM*TDEFFMN(IGEOEL)),
     1      TWHHYD           /(TOTHYDRO *HRSSIM*TDEFFMN(IHYDRO)),
     1      TWHWAV           /(TOTWAVE  *HRSSIM*TDEFFMN(IWAVE)),
     1      TWHTID           /(TOTTID   *HRSSIM*TDEFFMN(ITIDAL)),
     1      TWHTHEAT*CPERF1  /(TOTSHEAT *HRSSIM*TDEFFMN(ISOLTHM)),
     1      TWHGEOHT*CPERF1  /(TOTGHEAT *HRSSIM*TDEFFMN(IGEOHT)),
     1      TURBHYD          / TOTHYDRO
C
C ***************************************************************************
C                PRINT INFO ABOUT HYDROGEN, STORAGE, DISCHARGE
C ***************************************************************************
C H2CURMAX  = MAX TWH-ELEC USED TO PRODUCE/COMPRESS/STORE NON-GRID-H2 DURING SIM
C TWHH2TOT  = TOTAL TWH/YR ELEC NEEDED ALL SECTORS 2050 TO PROD/COMPRESS/STORE H2
C             THIS NUMBER IS AFTER T&D LOSSES, SO T&D LOSSES MUST BE ADDED TO THESE
C FRCH2STOR = MAX FRACTION OF TWH/YR OF H2 PRODUCED+CONSUMED THAT CAN BE STORED
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C           = DAYH2STOR / DAYSPY = 0.27 (100/365) WHEN DAYH2STOR = 100.
C             COST OF STORING EVERY KG-H2 PRODUCED UP TO FRCH2STOR=1 ACCOUNTED FOR
C POWMXIN   = MAX POWER (TW) ADDED TO ELEC STORAGE (AFTER LOSSES SUBTRACTED)
C POWMXOUT  = MAX POWER (TW) TAKEN OUT OF ELEC STORAGE (INCLUDING LOSSES)
C SUPPMAX   = MAX TW OF WIND+SOLAR POWER SUPPLIED ANY TIME DURING YEAR
C STORH2MX  = MAX TWH OF GRID H2 STORED ANYTIME DURING SIMULATION
C STORFTWH  = MAX STORAGE CAPACITY (TWH) OF ENERGY TO MAKE H2 FOR GRID ELEC STORAGE
C           = ENERGY IN ELECTRICITY USED TO PRODUCE/COMPRESS HYDROGEN
C
      WRITE(IOUT,257) PCT * H2CURMAX/TWHH2TOT, H2CURMAX, PCT*FRCH2STOR
      WRITE(IOUT,258) PCT * POWMXOUT / SUPPMAX, SUPPMAX
      WRITE(IOUT,259) PCT * POWMXIN  / SUPPMAX
      WRITE(IOUT,260) POWMXOUT, POWMXIN
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       WRITE(IOUT,361) PCT *STORH2MX/(H2STORMX+SMAL30),STORH2MX,H2STORMX
      ELSE
       WRITE(IOUT,362) PCT *STORH2MX/(STORFTWH+SMAL30),STORH2MX,STORFTWH
      ENDIF
C
C ***************************************************************************
C                           PRINT COST STATISTICS
C ***************************************************************************
C BLOADRES  = 2050 RESIDENTIAL      WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADCOM  = 2050 COMMERCIAL       WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADIND  = 2050 INDUSTRIAL       WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADTRA  = 2050 TRANSPORTATION   WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADAGF  = 2050 AG/FORESTRY/FISH WWS LOAD (GW) AFTER HEAT PUMPS
C BLOADOTH  = 2050 OTHER            WWS LOAD (GW) AFTER HEAT PUMPS
C TWHSUPPLY = TOTAL TWH OF ENERGY SUPPLIED BY WIND+SOLAR DURING SIMULATION
C             AFTER T&D LOSSES ACCOUNTED FOR. THIS INCLUDES CURTAILED WIND/SOL
C TWHHYD    = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHPKHYD  = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHBSHYD  = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C TWHWAV    = CUMULATIVE TWH WAVE PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHGEOEL  = CUMULATIVE TWH GEOTHERMAL ELEC PROD DURING SIM (AFTER T&D LOSSES)
C TWHTID    = CUMULATIVE TWH TIDAL PRODUCED DURING SIMULATION (AFTER T&D LOSSES)
C TWHSTCSP  = CUMULATIVE TWH OF CSP THAT GOES STRAIGHT TO STORAGE (AFTER T&D LOSS)
C ENDLOAD   = TWH OF ALL ENERGY USED OVER SIMULATION FOR END USE LOADS
C
C COSTLDTLO = LOW COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C COSTLDTMN = MEAN COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C COSTLDTHI = HIGH COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C
C FROM 50-STATE SPREADSHEET 'HVDC TRANSMISSION COST TAB' ROW 39
C        ASSUMES SOCIAL DISCOUNT RATE AS USED HERE
C        ASSUMES 100% OF ELECTRICITY PRODUCED IS TRANSMITTED
C        SEE ALSO JACOBSON ET AL., 2017, JOULE, TABLE S28, BOTTOM)
C        BASED ON COST OF $382 (295-447)/MW-KM (USD 2007)
C        COST OF HVDC TRANSMISSION SYSTEM, INCLUDING STATION EQUIP.
C
      COSTLDTLO  = 0.42
      COSTLDTMN  = 0.89
      COSTLDTHI  = 1.00
C
C TSUMELEC  = TWH ALL WIND + ALL SOLAR + HYDRO + WAVE + GEOTHERM + TIDAL
C             ELECTRICITY BEFORE T&D LOSSES
C TSUMWIND  = TWH ON+OFFSHORE WIND PRODUCED DURING SIM BEFORE T&D LOSS
C TSUMSOL   = TWH SOL PV+CSP PRODUCED DURING SIM BEFORE T&D LOSS
C FRACLDTR  = FRACTION OF TOTAL ENERGY PRODUCED BEFORE LOSSES THAT
C             IS TRANSMITTED LONG DISTANCE
C FLDISELEC = FRAC (DEFAULT 0.3) OF ALL END-USE ELECTRICITY SUBJECT TO HVDC LONG-DIST
C             TRANSMISSION (1500-2000 KM). FOR SMALL REGIONS (E.G., ISLANDS),
C             TRANSMISSION DISTANCES ARE SMALLER THUS FLDISELEC SHOULD
C             BE PROPORTIONATELY SMALLER
C TWHTMIT   = TWH ELECTRICITY TRANSMITTED LONG DIST 1750 (1500-2000) KM DURING SIM
C TSUPORIG  = SUPPLY (TWH) OVER SIM OF ALL ELEC+HEAT BEFORE T&D LOSSES=SUMNLS
C CUMSHED   = CUM WIND+SOLAR CURTAILED (TWH) OVER SIMULATION
C TOTROOFPV = TOTAL NEW+EXISTING INSTALLED RES + COMM/GOV ROOF PV CAPACITY (TW)
C TOTUTILPV = TOTAL NEW+EXISTING INSTALLED UTILITY SCALE PV CAPACITY (TW)
C TOTCSP    = TOTAL NEW+EXISTING INSTALLED CSP INSTALLED CAPACITY (TW)
C UPVFRAC   = FRACTION OF TOTAL SOLAR ELECTRICITY THAT IS NOT ROOFTOP
C
      UPVFRAC   = (TOTUTILPV+TOTCSP)/(TOTUTILPV+TOTCSP+TOTROOFPV)
      TSUMELEC  = TSUMWIND + TSUMSOL*UPVFRAC + TSUMHYD + TSUMWAV
     1          + TSUMGEO  + TSUMTID
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```
      TWHTMIT   = FLDISELEC * MAX(TSUMELEC-CUMSHED,0.)
      FRACLDTR  = TWHTMIT / TSUPORIG
C
C TRCOSTLO  = LO COST (CENTS/KWH) 1500-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C TRCOSTMN  = MID COST (CENTS/KWH) 1500-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C TRCOSTHI  = HI COST (CENTS/KWH) 1500-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C
      TRCOSTLO  = FRACLDTR * COSTLDTLO
      TRCOSTMN  = FRACLDTR * COSTLDTMN
      TRCOSTHI  = FRACLDTR * COSTLDTHI
C
C ANNLDLO   = LO LONG-DISTANCE TRANSMISSION COST ($TRIL/YR)
C ANNLDMN   = MEAN LONG-DISTANCE TRANSMISSION COST ($TRIL/YR)
C ANNLDHI   = HI LONG-DISTANCE TRANSMISSION COST ($TRIL/YR)
C TRILFACT  = CENTS-TW/(TRIL$-KW) = 100 CENTS/$/($TRIL/$ * 1.0E+09 KWH/TWH)
C TWHTMIT   = TWH ELECTRICITY TRANSMITTED LONG DIST (1200-2000 KM) DURING SIM
C COSTLDTLO = LOW COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C COSTLDTMN = MEAN COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C COSTLDTHI = HIGH COST OF LONG-DISTANCE TRANSMISSION (CENTS/KWH)
C TSUMHRS   = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C HRSPYR    = AVERAGE NUMBER OF HOURS PER YEAR DURING WHOLE SIMULATION
C
C THESE NUMBERS ARE NOT CURRENTLY USED SINCE ANNUAL COST OF TRANSMISSION
C IS WRAPPED INTO TOTAL ANNUAL COST OF ENERGY (SEE COEPKWHM)
C
      ANNLDLO   = (TWHTMIT / YEARSIM) * COSTLDTLO / TRILFACT
      ANNLDMN   = (TWHTMIT / YEARSIM) * COSTLDTMN / TRILFACT
      ANNLDHI   = (TWHTMIT / YEARSIM) * COSTLDTHI / TRILFACT
C
C ***************************************************************************
C      THE COST OF STORING EVERY KG-H2 PRODUCED IS ACCOUNTED FOR
C ***************************************************************************
C H2COSTLO  = LO COST (CENTS/KWH) NON-GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C H2COSTMN  = MEAN COST (CENTS/KWH) NON-GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C H2COSTHI  = HI COST (CENTS/KWH) NON-GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C COSH2KGL  = LO COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C             DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C COSH2KGM  = MN COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C COSH2KGH  = HI COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C AKGPKWH   = KG-NON-GRID-H2 PER KWH-OF-ALL ELECTRICITY USED DURING SIM FOR ALL
C             PURPOSES, MULTIPLIED BY 100 CENTS PER DOLLAR
C H2PRODTOT = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID H2 ELEC + NON-GRID H2 STORAGE
C           = H2PYNONG WHEN IMERGH2=0 OR 2
C H2PYNONG  = TG-H2/YR USED DURING SIM FOR NON-GRID USES = TGH2PYR
C ENDLOAD   = TWH OF ALL ENERGY USED OVER SIMULATION FOR END USE LOADS
C YEARSIM   = ACTUAL YEARS OF SIMULATION
C
      AKGPKWH  = 100. * H2PRODTOT * YEARSIM / ENDLOAD
      H2COSTLO = COSH2KGL * AKGPKWH
      H2COSTMN = COSH2KGM * AKGPKWH
      H2COSTHI = COSH2KGH * AKGPKWH
C
C COSTH2EL = LO COST (CENTS/KWH) GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C COSTH2EM = MEAN COST (CENTS/KWH) GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C COSTH2EH = HI COST (CENTS/KWH) GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C CGRH2KGL = LO COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C            FOR GRID H2 DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C CGRH2KGH = HIGH COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C H2PRODGR = ANNUAL H2 PRODUCED (TG-H2/YR) FOR GRID ELECTRICITY STORAGE
C ENDLOAD  = TWH OF ALL ENERGY USED OVER SIMULATION FOR END USE LOADS
C AKGPKWH  = KG-GRID-H2 PER KWH-OF-ALL ELECTRICITY USED DURING SIM FOR ALL
C            PURPOSES, MULTIPLIED BY 100 CENTS PER DOLLAR
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       AKGPKWH  = 100. * H2PRODTOT * YEARSIM / ENDLOAD
      ELSEIF (IMERGH2.EQ.2) THEN
       AKGPKWH  = 100. * H2PRODGR * YEARSIM / ENDLOAD
      ELSE
       AKGPKWH  = 0.
      ENDIF
      COSTH2EL = CGRH2KGL * AKGPKWH
      COSTH2EM = CGRH2KGM * AKGPKWH
      COSTH2EH = CGRH2KGH * AKGPKWH
C
C COSTEN    = LEVELIZED COST OF ENERGY (INC CAP+O&M+T&D LOSS+STOR+STOR LOSS+H2
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C             INCLUDES DECOMMISSIONING AND SHORT-DISTANCE TRANSMISSION
C             (U.S. CENTS/KWH)
C             ANNUALIZED WITH DISCOUNT RATE AND YEARLIFE. ACCOUNTS FOR
C             ONLY ENERGY ACTUALLY DELIVERED.
C             INCLUDES COST AND KWH OF ELECTRICITY AND HEAT
C COSTPOW   = LCOE POWER (CENTS/KWH) (INC CAP+O&M+T&D LOSS+H2,EXCLUDES STORAGE)
C             INCLUDES DECOMMISSIONING AND SHORT-DISTANCE TRANSMISSION
C             INCLUDES COST AND KWH OF ELECTRICITY AND HEAT
C COSTSTO   = LCOE NON-UTES STORAGE (CENTS/KWH) (INC CAP+O&M+T&D+STORAGE LOSS)
C COSTUGS   = LCOE NON STORAGE (CENTS/KWH) (INC CAP+O&M+T&D+STORAGE LOSS)
C ANNCOST   = TOTAL (CAPITAL + O&M) ANNUAL COST ($TRIL/YR)
C ANCOSPOW  = ANNUAL COST OF ELEC POWER, HEAT, H2 ($TRIL/YR) EXCLUDING STORAGE
C ANCOSSTO  = ANNUAL COST OF NON-UTES STORAGE ($TRIL/YR)
C ANCOSUGS  = ANNUAL COST OF UTES STORAGE ($TRIL/YR)
C TRILFACT  = CENTS-TW/(TRIL$-KW) = 100 CENTS/$/($TRIL/$ * 1.0E+09 KWH/TWH)
C SDTRANSL  = LO SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C SDTRANSM  = MEAN SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C SDTRANSH  = HI SHORT-DISTANCE TRANSMISSION COST (CENTS/KWH)
C TWHDELIV  = TWH DELIVERED POWER FROM ALL WWS SOURCES AFTER T&D LOSSES
C             DOES NOT INCLUDE DELIVERED POWER FROM PRE-EXISTING STORAGE
C
      TWHDELIV = TWHONWIN +TWHOFFWIN + TWHROOFPV + TWHUTILPV + TWHCSP
     1         + TWHHYD   +TWHWAV    + TWHGEOEL  + TWHTID    + TWHTHEAT
     1         + TWHGEOHT
C
      SDTRANSL=(TWHONWIN *SDTRCOSL(IONWIND)+TWHOFFWIN*SDTRCOSL(IOFFWIND)
     1        + TWHROOFPV*SDTRCOSL(IRESPV) +TWHUTILPV*SDTRCOSL(IUTILPV)
     1        + TWHCSP   *SDTRCOSL(ICSPSTOR)
     1        + TWHHYD   *SDTRCOSL(IHYDRO) + TWHWAV  *SDTRCOSL(IWAVE)
     1        + TWHGEOEL *SDTRCOSL(IGEOEL) + TWHTID  *SDTRCOSL(ITIDAL)
     1        + TWHTHEAT *SDTRCOSL(ISOLTHM)+ TWHGEOHT*SDTRCOSL(IGEOHT))
     1        / TWHDELIV
C
      SDTRANSH=(TWHONWIN *SDTRCOSH(IONWIND)+TWHOFFWIN*SDTRCOSH(IOFFWIND)
     1        + TWHROOFPV*SDTRCOSH(IRESPV) +TWHUTILPV*SDTRCOSH(IUTILPV)
     1        + TWHCSP   *SDTRCOSH(ICSPSTOR)
     1        + TWHHYD   *SDTRCOSH(IHYDRO) + TWHWAV  *SDTRCOSH(IWAVE)
     1        + TWHGEOEL *SDTRCOSH(IGEOEL) + TWHTID  *SDTRCOSH(ITIDAL)
     1        + TWHTHEAT *SDTRCOSH(ISOLTHM)+ TWHGEOHT*SDTRCOSH(IGEOHT))
     1        / TWHDELIV
C
      SDTRANSM = 0.5 * (SDTRANSL + SDTRANSH)
C
C TORIGLD   = 2050 ORIGINAL INFLEX+FLEX LOAD GOAL RES+COM+IND+TRANSP (TWH/YR)
C             THIS IS ENERGY ACTUALLY DELIVERED, SO DOES NOT INCLUDE
C             CURTAILED ENERGY, THUS IT IS THE CORRECT ENERGY TO USE FOR
C             COST OF ENERGY CALCS.
C TLFIN2050 = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C TENUSED   = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
C             AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR (FROM NEW+EXIST DEVICES)
C ENDLOAD   = TWH OF ALL ENERGY USED FOR END USE LOADS
C TSUMHRS   = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C HRSPYR    = AVERAGE NUMBER OF HOURS PER YEAR DURING WHOLE SIMULATION
C
      TORIGLD  = TLFIN2050 * HRSPYR
      TENUSED  = ENDLOAD   * HRSPYR / TSUMHRS
C
C COSTENL  = LO COST (CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C COSTENM  = MED COST(CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C COSTENH  = HI COST (CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C ANNCOSTL = LOW AN COST ($TRIL/YR) ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C          + HEAT PUMPS TO FEED HW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DISTANCE
C            TRANSMISSION. FOR NEW+EXISTING
C ANNCOSTM = MED ANNUAL COST ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C          + HEAT PUMPS TO FEED HW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DISTANCE
C            TRANSMISSION. FOR NEW+EXISTING
C ANNCOSTH = HI  ANNUAL COST ELEC+HEAT+ALL NON-H2 STORAGE+EXTRA HYDRO TURBINES
C          + HEAT PUMPS TO FEED HW-STES+UTES BUT NOT H2 OR SHORT T&D OR LONG-DISTANCE
C            TRANSMISSION. FOR NEW+EXISTING
C TRILFACT = CENTS-TW/(TRIL$-KW) = 100 CENTS/$/($TRIL/$ * 1.0E+09 KWH/TWH)
C
      COSTENL  = ANNCOSTL * TRILFACT / TENUSED + SDTRANSL + DISTRIBL
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```
      COSTENM  = ANNCOSTM * TRILFACT / TENUSED + SDTRANSM + DISTRIBM
      COSTENH  = ANNCOSTH * TRILFACT / TENUSED + SDTRANSH + DISTRIBH
C
C COSTPOWL  = LO COST (CENTS/KWH) ALL ELECTRIC POWER GENERATION
C COSTPOWM  = MED COST(CENTS/KWH) ALL ELECTRIC POWER GENERATION
C COSTPOWH  = HI COST (CENTS/KWH) ALL ELECTRIC POWER GENERATION
C ANCOSPOWL = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWM = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C ANCOSPOWH = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS ELEC DEVICES
C TENUSED   = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
C             AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR (FROM NEW+EXIST DEVICES)
C
      COSTPOWL = ANCOSPOWL * TRILFACT / TENUSED
      COSTPOWM = ANCOSPOWM * TRILFACT / TENUSED
      COSTPOWH = ANCOSPOWH * TRILFACT / TENUSED
C
C COSTHTL  = LO COST (CENTS/KWH) ALL HEAT GEN
C COSTHTM  = MED COST(CENTS/KWH) ALL HEAT GEN
C COSTHTH  = HI COST (CENTS/KWH) ALL HEAT GEN
C ANCOSHTL = LO $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTM = MN $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C ANCOSHTH = HI $TRIL ANNUALIZED CAPITAL/O&M/DECOMMIS COST NEW+EXIST WWS HEAT DEVICES
C
      COSTHTL = ANCOSHTL * TRILFACT / TENUSED
      COSTHTM = ANCOSHTM * TRILFACT / TENUSED
      COSTHTH = ANCOSHTH * TRILFACT / TENUSED
C
C COSTBATL = LOW COST (CENTS/KWH) BATTERY STORAGE
C COSTBATM = MED COST (CENTS/KWH) BATTERY STORAGE
C COSTBATH = HI  COST (CENTS/KWH) BATTERY STORAGE
C
      COSTBATL = ANCOSBATL * TRILFACT / TENUSED
      COSTBATM = ANCOSBATM * TRILFACT / TENUSED
      COSTBATH = ANCOSBATH * TRILFACT / TENUSED
C
C COSTSTOL = LOW COST (CENTS/KWH) CSP-PCM + PHS STORAGE
C COSTSTOM = MED COST (CENTS/KWH) CSP-PCM + PHS STORAGE
C COSTSTOH = HI  COST (CENTS/KWH) CSP-PCM + PHS STORAGE
C
      COSTSTOL = ANCOSSTOL * TRILFACT / TENUSED
      COSTSTOM = ANCOSSTOM * TRILFACT / TENUSED
      COSTSTOH = ANCOSSTOH * TRILFACT / TENUSED
C
C COSTSHTL = LOW COST (CENTS/KWH) HW-STES STORAGE
C COSTSHTM = MED COST (CENTS/KWH) HW-STES STORAGE
C COSTSHTH = HI  COST (CENTS/KWH) HW-STES STORAGE
C
      COSTSHTL = ANCHTSTOL * TRILFACT / TENUSED
      COSTSHTM = ANCHTSTOM * TRILFACT / TENUSED
      COSTSHTH = ANCHTSTOH * TRILFACT / TENUSED
C
C COSTSCLL = LOW COST (CENTS/KWH) CW-STES + PCM-ICE STORAGE
C COSTSCLM = MED COST (CENTS/KWH) CW-STES + PCM-ICE STORAGE
C COSTSCLH = HI  COST (CENTS/KWH) CW-STES + PCM-ICE STORAGE
C
      COSTSCLL = ANCCLSTOL * TRILFACT / TENUSED
      COSTSCLM = ANCCLSTOM * TRILFACT / TENUSED
      COSTSCLH = ANCCLSTOH * TRILFACT / TENUSED
C
C COSTHPTL = LO COST (CENTS/KWH) ADDITIONAL CONVENTIONAL HYDRO TURBINES
C COSTHPTM = MED COST(CENTS/KWH) ADDITIONAL CONVENTIONAL HYDRO TURBINES
C COSTHPTH = HI COST (CENTS/KWH) ADDITIONAL CONVENTIONAL HYDRO TURBINES
C ANCOSHPTL = LOW  ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTM = MEAN ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C ANCOSHPTH = HIGH ANNUAL TOTAL (CAP+O&M) COST OF ADDED HYDRO TURBINES($TRIL/YR)
C
      COSTHPTL = ANCOSHPTL * TRILFACT / TENUSED
      COSTHPTM = ANCOSHPTM * TRILFACT / TENUSED
      COSTHPTH = ANCOSHPTH * TRILFACT / TENUSED
C
C COSTUGSL = LO COST (CENTS/KWH) UTES STORAGE
C COSTUGSM = MED COST(CENTS/KWH) UTES STORAGE
C COSTUGSH = HI COST (CENTS/KWH) UTES STORAGE
C
      COSTUGSL = ANCOSUGSL * TRILFACT / TENUSED
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      COSTUGSM = ANCOSUGSM * TRILFACT / TENUSED
      COSTUGSH = ANCOSUGSH * TRILFACT / TENUSED
C
C COSTHBTL = LO COST (CENTS/KWH) BRICK INDUSTRIAL HEAT BATTERY STORAGE
C COSTHBTM = MED COST(CENTS/KWH) BRICK INDUSTRIAL HEAT BATTERY STORAGE
C COSTHBTH = HI COST (CENTS/KWH) BRICK INDUSTRIAL HEAT BATTERY STORAGE
C
      COSTHBTL = ANCOSHBTL * TRILFACT / TENUSED
      COSTHBTM = ANCOSHBTM * TRILFACT / TENUSED
      COSTHBTH = ANCOSHBTH * TRILFACT / TENUSED
C
C COSTSHPL  = LOW COST (CENTS/KWH) HEAT PUMPS FOR HW-STES+UTES STORAGE
C COSTSHPM  = MED COST (CENTS/KWH) HEAT PUMPS FOR HW-STES+UTES STORAGE
C COSTSHPH  = HI  COST (CENTS/KWH) HEAT PUMPS FOR HW-STES+UTES STORAGE
C ANCOSSHPL = LOW  ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C ANCOSSHPM = MED  ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C ANCOSSHPH = HI   ANNUAL TOTAL (CAP+O&M) COST HEAT PUMPS FOR STORAGE ($TRIL/YR)
C
      COSTSHPL = ANCOSSHPL * TRILFACT / TENUSED
      COSTSHPM = ANCOSSHPM * TRILFACT / TENUSED
      COSTSHPH = ANCOSSHPH * TRILFACT / TENUSED
C
C ***************************************************************************
C        NON-GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE CAPITAL COST
C ***************************************************************************
C CAPH2L = LO NON-GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE CAP COST ($TRIL)
C CAPH2M = MID NON-GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE CAP COST ($TRIL)
C CAPH2H = HI NON-GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE CAP COST ($TRIL)
C
      CAPH2L = CAPELYZL + CAPCOMPL + CAPSTORL
      CAPH2M = CAPELYZM + CAPCOMPM + CAPSTORM
      CAPH2H = CAPELYZH + CAPCOMPH + CAPSTORH
C
C ***************************************************************************
C       GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE, FUEL CELL CAPITAL COST
C ***************************************************************************
C CAPGRH2L   = LO GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE, FUEL CELL CAP COST ($TRIL)
C CAPGRH2M   = MID GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE FUEL CELL, CAP COST ($TRIL)
C CAPGRH2H   = HI GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE FUEL CELL CAP COST ($TRIL)
C CAPGRELYZL = ELECTROLYZER+RECTIFIER FOR GRID H2 LOW CAPITAL COST ($TRIL)
C CAPGRCOMPL = COMPRESSORS FOR GRID H2 LOW CAPITAL COST ($TRIL)
C CAPSTORGRL = STORAGE LOW CAPITAL COST FOR GRID H2  ($TRIL)
C CAPFCL     = H2 FUEL CELL FOR GRID ELEC LOW CAPITAL COST ($TRIL)
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       CAPGRH2L = CAPFCL
       CAPGRH2M = CAPFCM
       CAPGRH2H = CAPFCH
      ELSEIF (IMERGH2.EQ.2) THEN
       CAPGRH2L = CAPGRELYZL + CAPGRCOMPL + CAPSTORGRL + CAPFCL
       CAPGRH2M = CAPGRELYZM + CAPGRCOMPM + CAPSTORGRM + CAPFCM
       CAPGRH2H = CAPGRELYZH + CAPGRCOMPH + CAPSTORGRH + CAPFCH
      ELSE
       CAPGRH2L = 0.
       CAPGRH2M = 0.
       CAPGRH2H = 0.
      ENDIF
C
C ***************************************************************************
C                   CAPITAL COST OF HVDC TRANSMISSION
C ***************************************************************************
C DISCOUNTL = LOW SOCIAL DISCOUNT RATE FOR INTERGENERATIONAL PROJECT
C             (SEE JACOBSON ET AL. JOULE, 2017)
C DISCOUNTM = MEAN DISCOUNT RATE (FRACTION ON 1 BILLION LOAN
C DISCOUNTH = HI DISCOUNT RATE (FRACTION ON 1 BILLION LOAN
C ALIFHVDCL = LOW LIFE TIME OF HVDC SYSTEM (YR)
C ALIFHVDCM = MED LIFE TIME OF HVDC SYSTEM (YR)
C ALIFHVDCH = HI LIFE TIME OF HVDC SYSTEM (YR)
C             LIFETIMES = AVG OF LINES/POLES OTHER EQUIP
C             'HVDC transmission cost' TAB 143-COUNTRY SPREADSHEET ROWS 25-26
C CRFLO     = LO CAPITAL RECOVERY FACTOR
C TRCOSTLO  = LO COST (CENTS/KWH) 1200-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C TRCOSTMN  = MID COST (CENTS/KWH) 1200-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C TRCOSTHI  = HI COST (CENTS/KWH) 1200-2000 KM TRANSMIS, AVG OVER ALL US ENERGY
C TENUSED   = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
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C             AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR
C CVER2     = MULTIPLY BY CVER2 TO CONVERT CENTS-TWH/KWH TO $TRILLION =
C           = 10^-14 $BILLION/CENTS x 10^9 KWH/TWH
C CAPHVDCL  = LO CAPITAL COST HVDC ($TRIL)
C CAPHVDCM  = MID CAPITAL COST HVDC ($TRIL)
C CAPHVDCH  = HI CAPITAL COST HVDC ($TRIL)
C
      ALIFHVDCL = 50.
      ALIFHVDCM = 45.
      ALIFHVDCH = 40.
      CVER2     = 1.0E-05
C
      FAC1      = (1.+DISCOUNTL)**ALIFHVDCL
      CRFL      = DISCOUNTL * FAC1 / (FAC1 - 1.)
      CAPHVDCL  = TRCOSTLO * TENUSED * CVER2  / CRFL
C
      FAC1      = (1.+DISCOUNTM)**ALIFHVDCM
      CRFM      = DISCOUNTM * FAC1 / (FAC1 - 1.)
      CAPHVDCM  = TRCOSTMN * TENUSED * CVER2 / CRFL
C
      FAC1      = (1.+DISCOUNTH)**ALIFHVDCH
      CRFH      = DISCOUNTH * FAC1 / (FAC1 - 1.)
      CAPHVDCH  = TRCOSTHI * TENUSED * CVER2 / CRFH
C
C ***************************************************************************
C      ESTIMATE MEAN KM OF HVDC TRANSMISSION LINES FOR JOBS CALCULATIONS
C COST OF HVDC TRANSMISS (INCLUDING STATION EQUIP) $382 (295-447)/MW-KM (USD 2007)
C          FROM 50-STATE SPREADSHEET 'HVDC TRANSMISSION COST TAB' ROW 39
C             SEE ALSO JACOBSON ET AL., 2017, JOULE, TABLE S28, BOTTOM)
C ***************************************************************************
C POWHVDC  = AVERAGE MW ELECTRICITY TRANSMITTED THROUGH HVDC LINES DURING SIMULATION
C TWHTMIT  = TWH ELECTRICITY TRANSMITTED LONG DIST 1750 (1500-2000) KM DURING SIM
C HRSSIM   = NUMBER OF HOURS OF SIMULATION (HOURS)
C TWPERMW  = TW PER MW (=0.000001)
C HVDCLINC = HVDC LINE COST ($/MWtr-KM)
C CFHVDC   = CAPACITY FACTOR OF HVDC LINE (FRACTION OF TIME THAT
C            ELECTRICITY TRANSMITTING THROUGH
C            FROM 50-STATE SPREADSHIEET HVDC TRANSMISSION COST TAB LINE 38
C DOLPKM   = HVDC LINE COST ($/KM)
C HVDCKM   = KM OF HVDC LINES NEEDED
C CAPHVDCM = MID CAPITAL COST HVDC ($TRIL)
C TRILPDOL = 1.0E-12  TRILLION DOLLARS PER DOLLAR
C OJOBHVDC = LONG-TERM, FULL-TIME OPERATION JOBS/KM/YR FOR HVDC
C            FROM 50-STATE SPREADSHIEET WWS JOB CREATION TAB
C CJOBHVDC = LONG-TERM, FULL-TIME CONSTRUCTION JOBS/KM/YR FOR HVDC
C            FROM 50-STATE SPREADSHIEET WWS JOB CREATION TAB ROW 211 FF
C HVDCJOBO = HVDC OPERATIONN JOBS/YR OVER REGION
C HVDCJOBC = HVDC CONSTRUCTION JOBS/YR OVER REGION
C CAPLINE  = NAMEPLATE CAPACITY OF LINE (MW)
C
      POWHVDC  = TWHTMIT / (HRSSIM * TWPERMW)
      HVDCLINC = 400.
      CFHVDC   = 0.5
      CAPLINE  = POWHVDC / CFHVDC
      DOLPKM   = HVDCLINC * CAPLINE
      IF (DOLPKM.GT.0.) THEN
       HVDCKM  = CAPHVDCM / (TRILPDOL * DOLPKM)
      ELSE
       HVDCKM  = 0.
      ENDIF
      OJOBHVDC = 0.08
      CJOBHVDC = 0.094
      HVDCJOBO = OJOBHVDC * HVDCKM
      HVDCJOBC = CJOBHVDC * HVDCKM
C
C ***************************************************************************
C                   SUM LCOES AMONG ALL COMPONENTS
C ***************************************************************************
C COEPKWHL = LO COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C          + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COEPKWHM = MED COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C          + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COEPKWHH = HI COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C          + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COSTENL  = LO COST (CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
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C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C COSTENM  = MED COST(CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C COSTENH  = HI COST (CENTS/KWH) ALL ELEC POWER GEN + SHORT-DIST T&D + ALL STORAGE
C            (BUT NOT GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED HW-STES+UTES
C H2COSTLO = LO COST (CENTS/KWH) NON-GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C COSTH2EL = LO COST (CENTS/KWH) GRID H2 AVG OVER ALL EN PROD WHETHER FOR H2 OR NOT
C
      COEPKWHL = COSTENL + TRCOSTLO + H2COSTLO + COSTH2EL
      COEPKWHM = COSTENM + TRCOSTMN + H2COSTMN + COSTH2EM
      COEPKWHH = COSTENH + TRCOSTHI + H2COSTHI + COSTH2EH
C
C COEANNL  = LO ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C COEANNM  = MED ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C COEANNH  = HI ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C TENUSED  = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
C            AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR
C CVER3    = MULTIPLY BY CVER3 TO CONVERT CENTS-TWH/KWH TO $BILLION =
C          = 10^-11 $BILLION/CENTS x 10^9 KWH/TWH
C
      CVER3    = 0.01
      COEANNL  = COEPKWHL * TENUSED  * CVER3
      COEANNM  = COEPKWHM * TENUSED  * CVER3
      COEANNH  = COEPKWHH * TENUSED  * CVER3
C
C ***************************************************************************
C                        COST OF NON-GRID H2
C ***************************************************************************
C H2ELECOSL = LO ANN COST ELEC FOR RECT/ELECTROLYZ/COMPR ($/KG-H2)
C H2ELECOSM = MN ANN COST ELEC FOR RECT/ELECTROLYZ/COMPR ($/KG-H2)
C H2ELECOSH = HI ANN COST ELEC FOR RECT/ELECTROLYZ/COMPR ($/KG-H2)
C H2ENERGY  = KWH/KG-H2-PRODUCED-AND-COMPRESSED (=TWH/TG-H2)
C           = ELECRICITY REQUIRED FOR H2 PRODUCTION AND COMPRESSION
C COEPKWHL  = LO COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C           + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COEPKWHM  = MED COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C           + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COEPKWHH  = HI COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C           + H2 + ALL ELEC, HEAT, COLD, H2 STORAGE + HEAT PUMPS FOR HOT STORAGE
C COSH2KGL  = LO COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C             DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C COSH2KGM  = MN COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C COSH2KGH  = HI COST OF H2 ELECTROLYZER, COMPRESSOR, STORAGE, WATER ($/KG-H2)
C TOTH2L    = LO  TOTAL COST OF H2 ($/KG-H2), INCLUDING ELECTRICITY COST
C TOTH2M    = MED TOTAL COST OF H2 ($/KG-H2), INCLUDING ELECTRICITY COST
C TOTH2H    = HI  TOTAL COST OF H2 ($/KG-H2), INCLUDING ELECTRICITY COST
C
      H2ELECOSL = COEPKWHL * H2ENERGY / 100.
      H2ELECOSM = COEPKWHM * H2ENERGY / 100.
      H2ELECOSH = COEPKWHH * H2ENERGY / 100.
      TOTH2L    = COSH2KGL + H2ELECOSL
      TOTH2M    = COSH2KGM + H2ELECOSM
      TOTH2H    = COSH2KGH + H2ELECOSH
C
      WRITE(IOUT,383) H2ELECOSL,  H2ELECOSM, H2ELECOSH,
     1                ANCOSELYZL, ANCOSELYZM,ANCOSELYZH,
     1                ANCOSCOMPL, ANCOSCOMPM,ANCOSCOMPH,
     1                ANCOSWATL,  ANCOSWATM, ANCOSWATH,
     1                ANCOSH2STL, ANCOSH2STM,ANCOSH2STH,
     1                H2COSDISL,  H2COSDISM, H2COSDISH,
     1                H2CCOOLL,   H2CCOOLM,  H2CCOOLH,
     1                TOTH2L,     TOTH2M,    TOTH2H
C
 383  FORMAT('COST OF NON-GRID HYDROGEN'/
     1       'H2ELECOS  (LO MN HI ELEC $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCOSELYZ (LO MN HI ELYZ $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCOSCOMP (LO MN HI COMP $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCOSWAT  (LO MN HI WATER $/KG-H2)  = ',3(1X,0PF12.5),/
     1       'ANCOSH2ST (LO MN HI STOR $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'H2COSDIS  (LO MN HI DISPENS $/KG-H2)= ',3(1X,0PF12.5),/
     1       'H2CCOOL   (LO MN HI COOLING $/KG-H2)= ',3(1X,0PF12.5),/
     1       'TOTNONGH2 (LO MN HI TOT H2 $/KG-H2) = ',3(1X,0PF12.5),/)
C
C ***************************************************************************
C                             COST OF GRID H2
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C ************************************************************************
C IMERGH2  = 0: DO NOT INCLUDE ANY H2 FOR GRID ELECTRICITY
C          = 1: MERGE ELECTROLYZERS, COMPRESSORS, & STORAGE FOR
C               GRID AND NON-GRID H2. HERE, INCLUDE ONLY COST OF FUECL
C               CELLS SINCE REST COVERED ALREADY
C          = 2: KEEP ELECTROLYZERS, COMPRESSORS, & STORAGE
C               SEPARATE FOR GRID VERSUS NON-GRID H2
C          = 3: SAME AS IMERGH2=1, EXCEPT BATDISCH=0 (NO BATTERIES)
C CGRH2KGL = LO COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C            FOR GRID H2 DOESNT INCLUDE COST OF ELECTRICITY TO RUN ELECTROLYER OR COMPRESSOR
C CGRH2KGH = HIGH COST OF H2 ELECTROLYZER, WATER, COMPRESSOR, STORAGE, FUEL CELL ($/KG-H2)
C
      IF (IMERGH2.EQ.1.OR.IMERGH2.EQ.3) THEN
       WRITE(IOUT,384) 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 ANCGRFCL,   ANCGRFCM,  ANCGRFCH,
     1                 ANCGRFCL,   ANCGRFCM,  ANCGRFCH
      ELSEIF (IMERGH2.EQ.2.AND.FCCHARG+FCDISCH.GT.0.) THEN
       TOTH2L    = CGRH2KGL + H2ELECOSL
       TOTH2M    = CGRH2KGM + H2ELECOSM
       TOTH2H    = CGRH2KGH + H2ELECOSH
       WRITE(IOUT,384) H2ELECOSL,  H2ELECOSM, H2ELECOSH,
     1                 ANCGRELYZL, ANCGRELYZM,ANCGRELYZH,
     1                 ANCGRCOMPL, ANCGRCOMPM,ANCGRCOMPH,
     1                 ANCOSWATL,  ANCOSWATM, ANCOSWATH,
     1                 ANCGRH2STL, ANCGRH2STM,ANCGRH2STH,
     1                 ANCGRFCL,   ANCGRFCM,  ANCGRFCH,
     1                 TOTH2L,     TOTH2M,    TOTH2H
      ELSE
       WRITE(IOUT,384) 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.,
     1                 0.,         0.,        0.
      ENDIF
C
 384  FORMAT('COST OF GRID HYDROGEN'/
     1       'H2ELECOS  (LO MN HI ELEC $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCGRELYZ (LO MN HI ELYZ $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCGRCOMP (LO MN HI COMP $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCOSWAT  (LO MN HI WATER $/KG-H2)  = ',3(1X,0PF12.5),/
     1       'ANCGRH2ST (LO MN HI STOR $/KG-H2)   = ',3(1X,0PF12.5),/
     1       'ANCGRFC   (LO MN HI FUELCEL $/KG-H2)= ',3(1X,0PF12.5),/
     1       'TOTGRIDH2 (LO MN HI TOT H2 $/KG-H2) = ',3(1X,0PF12.5),/)
C
C ************************************************************************
C PRINT 2050 MEAN BAU LCOE, HEALTH, CLIMATE COSTS ($2013 U.S. CENTS/KWH)
C ************************************************************************
C BAULOADR   = REGION 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOER   = REGION 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALR   = REGION 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C              COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C              MORTALITY NUMBERS AMORT50F, AMOTCURF INCLUDE ALL AIR POL DEATHS
C BAUCLIMR   = REGION 2050 BAU CLIM COST ($2013 CENTS/KWH-ALL-ENERGY) IN
C ELECONLY   = WWS LCOE (C/KWH) OF BAU ELEC SECTOR ELECTRICITY ONLY (SEE ABOVE)
C BAUSOCC    = REGION 2050 BAU SOCIAL COST (C/KWH) OF ENERGY (LCOE+HEALTH+CLIM)
C TLFIN2050  = TOTAL 2050 ALL-SECTOR LOAD WITH WWS (TW) AFTER HEAT PUMPS
C RATLCOE    = RATIO WWS:BAU ENERGY COST ONLY IN 2050
C RATBAUES   = RATIO BAU-ENERGY-COST TO BAU-SOCIAL-COST (EN+HEALTH+CLIM)
C RATLOAD    = RATIO WWS:BAU END-USE LOAD 2050
C RATCOST    = RATLCOE*RATBAUES=COEPKWHM/BAULCOER
C            = RATIO WWS:BAU SOCIAL COST PER UNIT ENERGY IN 2050
C SCRATIO    = RATLCOE*RATBAUES*RATLOAD = OVERALL SOCIAL COST RATIO WWS:BAU
C COEPKWHM   = MED COST (CENTS/KWH) ALL ELEC+HEAT GEN + SHORT+LONG DIST T&D
C            + H2 + ALL ELECTRICITY, HEAT, COLD, H2 STORAGE
C TENUSED    = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
C              AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR
C
      BAUSOCC  =BAULCOER(IGRIDUSE)+BAUHEALR(IGRIDUSE)+BAUCLIMR(IGRIDUSE)
C     ELECONLY = COSTPOWM+COSTHTM+COSTBATM+COSTSTOM+COSTSCLM+COSTHPTM
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C    1         + TRCOSTMN*(1.-FRCH2ALL)+SDTRANSM+DISTRIBM
C     RATCOST  = ELECONLY           / BAUSOCC
      RATLCOE  = COEPKWHM           / BAULCOER(IGRIDUSE)
      RATBAUES = BAULCOER(IGRIDUSE) / BAUSOCC
      RATCOST  = RATLCOE * RATBAUES
      RATLOAD  = TLFIN2050 * GWPTW  / BAULOADR(IGRIDUSE)
      SCRATIO  = RATCOST * RATLOAD
C
      WRITE(IOUT,286) BAULOADR(IGRIDUSE), BAULCOER(IGRIDUSE),
     1                BAUHEALR(IGRIDUSE), BAUCLIMR(IGRIDUSE),
     1                BAUSOCC, COEPKWHM, RATLCOE, RATBAUES, RATLOAD,
     1                SCRATIO, RATCOST
C
C ***************************************************************************
C  PRINT ABSOLUTE ENERGY, HEALTH, CLIMATE COSTS AND AIR POL MORTALITIES
C ***************************************************************************
C BAUTWHY   = TWH/YR OF END-USE BAU ENERGY USED IN 2050 FROM END-USE LOAD
C           = BAULOADR(IGRIDUSE)*AVHRSPYR/GWPTW (USE SO GET SAME
C             RESULT FOR A STATE OR COUNTRY WHEN ISOLATED VS
C             INTERCONNECTED)
C           = TENUSED/RATLOAD (USE THIS SINCE EXACTLY CONSISTENT W/WWS
C RATLOAD   = RATIO WWS:BAU END-USE LOAD 2050
C TENUSED   = 2050 ANNUAL-AVERAGE END-USE ENERGY PROD FROM SIMULATION (TWH/YR)
C             AFTER ALL LOSSES OF ENERGY ACCOUNTED FOR
C BAUBILE   = $BIL/YEAR COST OF BAU ENERGY (ASSUMES ALL ENERGY SAME
C             COST/KWH AS ELECTRICITY)
C BAUBILH   = $BIL/YEAR HEALTH COST 2050 DUE TO BAU ENERGY
C BAUBILC   = $BIL/YEAR CLIMATE COST 2050 DUE TO BAU ENERGY
C BAUBILT   = $BIL/YEAR ENERGY+HEALTH+CLIM COST 2050 FROM BAU ENERGY
C BAUHEALR  = REGION 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C             COST REDUCED 10% SINCE ONLY 90% OF MORTALITIES DUE TO BAU ENERGY
C             MORTALITY NUMBERS AMORT50F, AMOTCURF INCLUDE ALL AIR POL DEATHS
C CVER3     = MULTIPLY BY CVER3 TO CONVERT CENTS-TWH/KWH TO $BILLION =
C           = 10^-11 $BILLION/CENTS x 10^9 KWH/TWH
C AVHRSPYR  = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C COEANNM   = MED ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C AMORTCURR = 2016 AIR POL MORTALITY BY REGION IN ARRAY
C AMORT50R  = 2050 AIR POL MORTALITY BY REGION IN ARRAY
C VOSL      = VALUE ($MIL/DEATH) OF STATISTICAL LIFE+MORBIDITY+NON-HEALTH PROBS
C FMORTBAU  = FRACTION OF ALL AIR POLLUTION DEATHS DUE TO BAU ENERGY
C           = 0.9 FROM 143-COUNTRY SPREADSHEET WHERE AP COSTS CALCULATED
C
C     BAUTWHY  = TENUSED / RATLOAD
      BAUTWHY  = BAULOADR(IGRIDUSE) * AVHRSPYR / GWPTW
      BAUBILE  = BAULCOER(IGRIDUSE) * BAUTWHY * CVER3
      BAUBILH  = BAUHEALR(IGRIDUSE) * BAUTWHY * CVER3
      BAUBILC  = BAUCLIMR(IGRIDUSE) * BAUTWHY * CVER3
      BAUBILT  = BAUBILE + BAUBILH + BAUBILC
C
      VOSL     = BAUBILH * 1000. / (AMORT50R(IGRIDUSE) * FMORTBAU)
C
      WRITE(IOUT,287) BAUBILE, BAUBILH, BAUBILC, BAUBILT, COEANNM,
     1                AMORTCURR(IGRIDUSE), AMORT50R(IGRIDUSE), VOSL
C
C ***************************************************************************
C        PRINT 2050 $/TONNE-CO2E FOR PRIVATE ENERGY & SOCIAL COSTS
C ***************************************************************************
C CO2E2050R = REGION TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C BAUBILE   = $BIL/YEAR COST OF BAU ENERGY (ASSUMES ALL ENERGY SAME
C             COST/KWH AS ELECTRICITY)
C BAUBILH   = $BIL/YEAR HEALTH COST 2050 DUE TO BAU ENERGY
C BAUBILC   = $BIL/YEAR CLIMATE COST 2050 DUE TO BAU ENERGY
C BAUBILT   = $BIL/YEAR ENERGY+HEALTH+CLIM COST 2050 FROM BAU ENERGY
C COEANNM   = MED ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C
      C9 = 1.0E9/CO2E2050R(IGRIDUSE)
      WRITE(IOUT,301) BAUBILE*C9,BAUBILH*C9,BAUBILC*C9,BAUBILT*C9,
     1                COEANNM*C9, CO2E2050R(IGRIDUSE)/1.0E6
C
C ***************************************************************************
C                          PRINT JOB CREATION AND LOSS
C ***************************************************************************
C ***************************************************************************
C        STORAGE CONSTRUCTION, MANUFACTURING< AND DECOMMISSIONING JOBS
C       THESE JOBS WILL BE PARTITIONED BY COUNTRY PROPORTIONALLY TO LOAD
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C ************************************************************************
C CONVLIFE  = MW/TW-YRS = CONVERTS JOB-YRS/MW x TW TO JOBS
C STORLIFEM = LIFETIME (YEARS) OF STORAGE DEVICES THAT GIVES MEAN COST
C STORCJOB  = REGIONAL CONSTRUC+MANUFAC+DECOMISS JOBS STORAGE (JOB-YRS/MW)
C             FOR STORAGE, PER MW PEAK DISCHARGE RATE
C             FOR H2, PER MW NEEDED FOR ELECTROLYSIS AND COMPRESSION
C CJOBSTOR  = REGIONAL # LONG-TERM, FULL-TIME MANUF/CONSTRUC/DECOMIS STORAGE JOBS
C TSTORPHS  = MAX DISCHARGE & CHARGE RATE PUMPED HYDRO STORAGE (TW)
C TEXISTPHS = PRE-EXISTINGPUMPED-HYDRO STORAGE (PHS) NAMEPLATE CAPACITY (TW)
C CSPDISCH  = MAX DISCHARGE RATE (TW) OF CSP EITHER FROM STORAGE OR DIRECTLY
C BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C CHILDISCH = MAX DISCHARGE AND CHARGE RATE (TW) CHILLED-WATER (CW)-STES STORAGE
C PCMDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) PCM-ICE STORAGE
C HOTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF HOT WATER (HW)-STES
C             REALLY MAX DISCHARGE AND CHARGE RATE OF ELECTRICITY TO
C             PRODUCE THE HEAT SINCE HEAT LOAD CONVERTED TO ELECTRICAL LOAD
C             THAT WOULD PRODUCE THAT HEAT WITH HEAT PUMPS IN
C             countrystats.dat
C FCDISCH   = MAX DISCHARGE RATE (TW) OF ELECTRICITY FROM H2 FUEL CELLS
C           = MAX DISCHARGE RATE (TW) OF ELEC FROM GRID-H2 STORAGE
C             MULTIPLIED BY H2DCEFF * H2CHAREFF
C UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C             SINCE HEATING IS PROVIDED BY HEAT PUMPS AND HEATING LOAD
C             WAS CONVERTED TO EQUIVALENT ELECTRICAL LOAD IN
C             countrystats.dat, THIS MAX DISCHARGE RATE IS OF
C             ELECTRICITY TO PROVIDE THE HEAT FROM HEAT PUMPS
C HBTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF INDUSTRIAL HEAT BATTERIES
C HPSIZE    = SIZE (TW-ELEC) OF HEAT PUMPS TO HEAT HW-STES+UTES
C             AND TO COOL CW-STES
C H2LDPEAKI = PEAK INSTANT LOAD (TW) FOR H2 ELECTROLYSIS+COMPRESSION OVER SIM
C ELYZLIFE  = LIFETIME (YR) OF ELECTROLYZER CORRESPONDING TO USE FACTOR H2USEFACI
C TWPERMW   = 0.000001 TERAWATTS (TW) PER MEGAWATT (MW)
C
      IF (IMERGH2.EQ.2) THEN
       GRIDCHAR = FCCHARG
      ELSE
       GRIDCHAR = 0.
      ENDIF
C
      CONVLIFE = 1. / (TWPERMW * STORLIFEM)
      CJOBSTOR = CONVLIFE *(STORCJOB(1)*MAX(TSTORPHS-TEXISTPHS,0.)
     1                    + STORCJOB(2)*CSPDISCH +STORCJOB(3)*BATDISCH
     1                    + STORCJOB(8)*FCDISCH
     1                    + STORCJOB(4)*CHILDISCH+STORCJOB(5)*PCMDISCH
     1                    + STORCJOB(6)*HOTDISCH +STORCJOB(7)*UTESDISCH
     1                    + STORCJOB(9)*HPSIZE   +STORCJOB(10)*HBTDISCH)
     1                    + STORCJOB(8)*GRIDCHAR /(TWPERMW * ELYZLIFE)
     1                    + STORCJOB(8)*H2LDPEAKI/(TWPERMW * ELYZLIFE)
C
C ************************************************************************
C                   STORAGE OPERATION AND MAINTENANCE JOBS
C       THESE JOBS WILL BE PARTITIONED BY COUNTRY PROPORTIONALLY TO LOAD
C ************************************************************************
C OJOBSTOR  = # LONG-TERM, FULL-TIME O&M STORAGE JOBS
C STOROJOB  = OPERATION AND MAINTENANCE (O&M) JOBS STORAGE (JOBS/MW)
C             FOR STORAGE, PER MW PEAK DISCHARGE RATE
C             FOR H2, PER MW NEEDED FOR ELECTROLYSIS AND COMPRESSION
C             1= PHS; 2=PCM-CSP; 3=BATTERIES; 4=CW-STES; 5=PCM-ICE;
C             6=HW-STES; 7=UTES; 8=HYDROGEN; 9=HEAT PUMPS
C TLOADH2   = AVG LOAD (TW) FOR NON-GRID H2 PROD/COMPRESSION/STORAGE
C             (FOR H2 JOBS, USE AVG H2 LOAD SINCE MOST ELECTROLYZERS IDLE)
C
      OJOBSTOR = (1./TWPERMW)          *(STOROJOB(1)*TSTORPHS
     1         + STOROJOB(2)*CSPDISCH  + STOROJOB(3)*BATDISCH
     1         + STOROJOB(8)*FCDISCH
     1         + STOROJOB(4)*CHILDISCH + STOROJOB(5)*PCMDISCH
     1         + STOROJOB(6)*HOTDISCH  + STOROJOB(7)*UTESDISCH
     1         + STOROJOB(9)*HPSIZE    + STOROJOB(10)*HBTDISCH)
     1         + STOROJOB(8)*GRIDCHAR /TWPERMW
     1         + STOROJOB(8)*H2LDPEAKI/TWPERMW
C
C ************************************************************************
C          PARAMETERS FOR DETERMINING CAPITAL COST BY STATE/COUNTRY
C ************************************************************************
C ALLCAPC   = REGIONAL MEAN UP-FRONT CAPITAL COST ($TRILLION) OF
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C             NEW WWS DEVICES + STORAGE + HVDC + H2 INFRASTRUCTURE
C TRILTOTM  = MEAN UP-FRONT CAPITAL COST ($TRILLION) OF NEW WWS DEVICES + STORAGE
C CAPHVDCM  = MID CAPITAL COST HVDC ($TRIL)
C CAPH2M    = MID NON-GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE CAP COST ($TRIL)
C CAPGRH2M  = MID GRID H2 ELECTROLYZER, COMPRESSOR, STORAGE FUEL CELL, CAP COST ($TRIL)
C SUMCAPC   = SUM OF CAPITAL COST ($TRIL) OF GENERATORS OVER ALL STATES/
C             COUNTRIES IN A REGION. SHOULD = TRILMN + TRILHMN
C CAPNOTGEN = CAP COST ($TRIL) OF ALL NON-GENERATION (THUS STORAGE, HVDEC, H2)
C             PARTITION THIS BY STATE/COUNTRY BASED ON END-USE LOAD
C
      ALLCAPC   = TRILTOTM + CAPHVDCM + CAPH2M + CAPGRH2M
      CAPNOTGEN = ALLCAPC - SUMCAPC
C
C ***************************************************************************
C              DETERMINE JOB CREATION AND LOSS BY STATE OR COUNTRY
C ***************************************************************************
C
      TCONJOBR  = 0.
      TOBJOBR   = 0.
      CJOBTDR   = 0.
      OJOBTDR   = 0.
C
      DO I      = 1, NCOUNGRID(IGRIDUSE)
       IC       = NUMCOUNGR(IGRIDUSE,I)
C
C WWSTOT    = TOTAL 2050 END-USE LOAD (GW) FOR EACH 1..MXCOUNTRY COUNTRY
C SUMWWS    = SUM OF END-USE LOAD (GW) OVER ALL COUNTRIES IN DATASET
C RATIOLOAD = WWSTOT/SUMWWS = RATIO END-USE LOAD IN STATE/COUNTRY TO THAT IN REGION
C
       RATIOLOAD =  WWSTOT(IC) / SUMWWS(IGRIDUSE)
C
C CSPTURBFAC = RATIO OF MW OF CSP STEAM TURBINES DESIRED RELATIVE TO MW
C              ORIGINALLY INSTALLED FOR EACH CSP PLANT IN ORDER TO MEET
C              ANNUALLY AVERAGED POWER DEMAND FOR STATE OR COUNTRY
C              BEFORE CONSIDERING THE GRID.
C            = 1.  INDICATES NO ADDITIONAL TURBINE POWER NEEDED TO MATCH DEMAND
C            = 1.6 INDICATES 60% MORE MW OF POWER NEEDED TO MATCH POWER DEMAND
C                  ON GRID THAN NEEDED FOR ANNUALLY AVERAGED POWER DEMAND.
C TGWADCSPC  = ADDED CSP TURBINES (GW) IN STATE/COUNTRY FROM SPREADSHEET TO
C              MEET CONTINUOUS LOAD. USED ONLY TO CALCULATE JOB NUMBERS
C              NEW SPREADSHEETS SHOULD HAVE 0 VALUES
C              OLD SPREADSHEET VALUES WERE TWMCSPORIG*0.6
C CSPRATIO   = CSPTURBFAC / CSPTFORIG WHERE CSPTFORIG IS VALUE OF CSPTURBFAC USED TO
C              CALCULATE JOB NUMBERS IN ORIGINAL SPREADSHEET
C CSPTFORIG  = RATIO OF CSP TO MEET CONTINUOUS LOAD TO CSP TO MEET
C              ANN AVERAGE LOAD FROM SPREADSHEET. PREVIOUSLY=1.6. NOW 1.0
C
       IF (TGWINSTALL(IC,ICSPSTOR).GT.0.) THEN
        CSPTFORIG = (TGWINSTALL(IC,ICSPSTOR) + TGWADCSPC(IC))
     1            /  TGWINSTALL(IC,ICSPSTOR)
        CSPRATIO  = CSPTURBFAC / CSPTFORIG
       ELSE
        CSPRATIO  = 1.
       ENDIF
C
C ***************************************************************************
C               GENERATOR LONG-TERM, FULL-TIME CONSTRUCTION JOBS
C ***************************************************************************
C TCONJOBC  = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME CONSTRUCTION JOBS W/WWS
C             THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C             INCLUDES OF NEW DEVICES ONLY
C CONJOBR   = REGION LONG-TERM, FULL-TIME CONSTRUCTION JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. KEEP BASED ON NEW NAMEPLATE.
C              ADJUST HERE ONLY FOR NAMEPLATE CAPACITY.
C              THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C CJOBTDC   = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC
C             MANUF/CONSTRUC TRANSMIS JOBS
C HVDCJOBC  = HVDC CONSTRUCTION JOBS/YR OVER REGION
C RATIOLOAD = WWSTOT/SUMWWS = RATIO END-USE LOAD IN STATE/COUNTRY TO THAT IN REGION
C
C      CJOBTDC(IC)  = CONJOBC(IC,13)          + CONJOBC(IC,14)
       CJOBTDC(IC)  = CONJOBC(IC,13)          + HVDCJOBC * RATIOLOAD
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      TCONJOBC(IC) = CONJOBC(IC,1)*FACONWIN  + CONJOBC(IC,2)*FACOFFWIN
     1             + CONJOBC(IC,3)           + CONJOBC(IC,4)
     1             + CONJOBC(IC,5)           + CONJOBC(IC,6)
     1             + CONJOBC(IC,7)*FACRESPV  + CONJOBC(IC,8)*FACCOMPV
     1             + CONJOBC(IC,9)*FACUTILPV + CONJOBC(IC,10)*CSPRATIO
     1             + CONJOBC(IC,11)*FACSHT   + CONJOBC(IC,12)
     1             + CJOBTDC(IC)
C
C ***************************************************************************
C              GENERATOR LONG-TERM, FULL-TIME OPERATION JOBS
C ***************************************************************************
C ALLTONEW   = RATIO OF EXIST+NEW TO NEW NAMEPLATE CAPACITY 1..MXCAP
C              MULTIPLY OPJOBSR (BASED ON NEW JOBS) BY ALLTONEW TO
C              OBTAIN OP JOBS FOR EXISTIN+NEW DEVICES.
C            = -999. IF ALL DEVICES EXISTING (USE DEFOPJOB FOR OPERATION JOBS)
C            = 0. IF NO INSTALLATIONS AT ALL (THEN NO JOBS)
C TGWINSTREG = GW-SUM OVER REG J, 2050 NEW+EXIST NAMEPL CAPAC FOR DEVICE K
C EGWINSTREG = GW-SUM OVER REG J, EXISTING NAMEPL CAPAC FOR DEVICE K
C
       DO J        = 1, MXCAP
        ANEW       = TGWINSTALL(IC,J) - EGWINSTALL(IC,J)
        IF (TGWINSTALL(IC,J).LE.1.0E-06) THEN
         ALLTONEW(J) = 0.
        ELSEIF (ABS(ANEW).GT.1.0E-8) THEN
         ALLTONEW(J) = TGWINSTALL(IC,J)/ANEW
        ELSE
         ALLTONEW(J) = -999.
        ENDIF
       ENDDO

C TOPJOB    = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME OPERATION JOBS W/WWS
C             INCLUDES OF EXISTING PLUS NEW DEVICES
C OPJOBSC   = STATE/COUNTRY LONG-TERM, FULL-TIME OPERATIONAL JOBS CREATED, BASED ON
C              NEW NAMEPLATE CAPACITIES. ADJUST HERE SO FOR NEW+EXISTING
C              AND BASED ON UPDATED NAMEPLATE CAPACITIES
C              1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C              7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C              12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C DEFOPJOB = DEFAULT NUMBER OPERATION JOBS PER MW-NAMEPLATE FOR EACH TECH
C            1=ONWIND; 2=OFFWIND; 3=WAVE; 4=GEOELEC; 5=HYDRO; 6=TIDAL;
C            7=RESPV; 8=COMGOVPV; 9=UTILPV; 10=TOTALCSP; 11=SOLHEAT;
C            12=GEOHEAT; 13=CONVTRANSMIS; 14=HVDCTRANSMIS
C            (NOT NEEDED FOR TRANSMISSION HERE)
C GWPERMW  = 0.001    GIGAWATTS (GW) PER MEGAWATT (MW)
C
       TOPJOB = 0.
C
C JOBS FOR ONSHORE WIND
C
       IF (ALLTONEW(IONWIND).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,1)*FACONWIN*ALLTONEW(IONWIND)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(1)*FACONWIN*EGWINSTALL(IC,IONWIND)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR OFFSHORE WIND
C
       IF (ALLTONEW(IOFFWIND).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,2)*FACONWIN*ALLTONEW(IOFFWIND)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(2)*FACONWIN*EGWINSTALL(IC,IOFFWIND)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR WAVE
C
       IF (ALLTONEW(IWAVE).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,3)*ALLTONEW(IWAVE)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(3)*EGWINSTALL(IC,IWAVE)/GWPERMW
       ENDIF
C
C JOBS FOR GEOTHERMAL ELECTRICITY
C
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       IF (ALLTONEW(IGEOEL).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,4)*ALLTONEW(IGEOEL)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(4)*EGWINSTALL(IC,IGEOEL)/GWPERMW
       ENDIF
C
C JOBS FOR HYDRO
C
       IF (ALLTONEW(IHYDRO).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,5)*ALLTONEW(IHYDRO)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(5)*EGWINSTALL(IC,IHYDRO)/GWPERMW
       ENDIF
C
C JOBS FOR TIDAL
C
       IF (ALLTONEW(ITIDAL).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,6)*ALLTONEW(ITIDAL)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(6)*EGWINSTALL(IC,ITIDAL)/GWPERMW
       ENDIF
C
C JOBS FOR RESIDENTIAL PV
C
       IF (ALLTONEW(IRESPV).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,7)*FACRESPV*ALLTONEW(IRESPV)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(7)*FACRESPV*EGWINSTALL(IC,IRESPV)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR COMMERCIAL/GOVT ROOF PV
C
       IF (ALLTONEW(ICOMGVPV).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,8)*FACCOMPV*ALLTONEW(ICOMGVPV)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(8)*FACCOMPV*EGWINSTALL(IC,ICOMGVPV)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR UTILITY PV
C
       IF (ALLTONEW(IUTILPV).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,9)*FACUTILPV*ALLTONEW(IUTILPV)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(9)*FACUTILPV*EGWINSTALL(IC,IUTILPV)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR CSP
C
       IF (ALLTONEW(ICSPSTOR).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,10)*CSPRATIO*ALLTONEW(ICSPSTOR)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(10)*CSPRATIO*EGWINSTALL(IC,ICSPSTOR)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR SOLAR THERMAL HEAT
C
       IF (ALLTONEW(ISOLTHM).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,11)*FACSHT*ALLTONEW(ISOLTHM)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(11)*FACSHT*EGWINSTALL(IC,ISOLTHM)
     1         / GWPERMW
       ENDIF
C
C JOBS FOR GEOTHERMAL HEAT
C
       IF (ALLTONEW(IGEOHT).GE.0.) THEN
        TOPJOB = TOPJOB+OPJOBSC(IC,12)*ALLTONEW(IGEOHT)
       ELSE
        TOPJOB = TOPJOB+DEFOPJOB(12)*EGWINSTALL(IC,IGEOHT)/GWPERMW
       ENDIF
C
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C OPERATION JOBS FOR CONVENTIONAL AND HVDC TRANSMISSION
C  TOPJOB  = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME OPERATION JOBS W/WWS
C  OJOBTDC = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC O&M TRANSMIS JOBS
C
C HVDCJOBO  = HVDC OPERATIONN JOBS/YR OVER REGION
C RATIOLOAD = WWSTOT/SUMWWS = RATIO END-USE LOAD IN STATE/COUNTRY TO THAT IN REGION
C
C      OJOBTDC(IC) = OPJOBSC(IC,13) + OPJOBSC(IC,14)
       OJOBTDC(IC) = OPJOBSC(IC,13) + HVDCJOBO * RATIOLOAD
       TOPJOB      = TOPJOB + OJOBTDC(IC)
C
C **************************************************************************
C                 PARTITION STORAGE JOBS AND ADD TO OTHERS
C **************************************************************************
C **************************************************************************
C       JOBS FOR ELECTRICITY STORAGE, HEAT&COLD STORAGE, HYDROGEN
C **************************************************************************
C CJOBSTORC = # STATE/COUNTRY LONG-TERM, FULL-TIME MANUF/CONSTRUC/DECOMIS STORAGE JOBS
C OJOBSTORC = # STATE/COUNTRY LONG-TERM, FULL-TIME O&M STORAGE JOBS
C CJOBSTOR  = # REGIONAL LONG-TERM, FULL-TIME MANUF/CONSTRUC/DECOMIS STORAGE JOBS
C OJOBSTOR  = # REGIONAL LONG-TERM, FULL-TIME O&M STORAGE JOBS
C RATIOLOAD = WWSTOT/SUMWWS = RATIO END-USE LOAD IN STATE/COUNTRY TO THAT IN REGION
C
       CJOBSTORC(IC) = CJOBSTOR * RATIOLOAD
       OJOBSTORC(IC) = OJOBSTOR * RATIOLOAD
C
C TCONJOBC  = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME CONSTRUCTION JOBS W/WWS
C             THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C             INCLUDES OF NEW DEVICES ONLY
C TCONJOBR  = SUM OF TCONJOBC OVER ALL STATES/COUNTRIES IN A REGION
C TOPJOBC   = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME OPERATION JOBS W/WWS
C             INCLUDES OF EXISTING PLUS NEW DEVICES
C TOPJOBR   = SUM OF TOPJOBC OVER ALL STATES/COUNTRIES IN A REGION
C OJOBTDC   = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC O&M TRANSMIS JOBS
C OJOBTDR   = SUM OF OJOBTDC OVER ALL STATES/COUNTRIES IN A REGION
C CJOBTDC   = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC
C             MANUF/CONSTRUC TRANSMIS JOBS
C CJOBTDR   = SUM OF CJOBTDC OVER ALL STATES/COUNTRIES IN A REGION
C
       TCONJOBC(IC) = TCONJOBC(IC) + CJOBSTORC(IC)
       TOPJOBC( IC) = TOPJOB       + OJOBSTORC(IC)
       TCONJOBR     = TCONJOBR     + TCONJOBC( IC)
       TOPJOBR      = TOPJOBR      + TOPJOBC(  IC)
       CJOBTDR      = CJOBTDR      + CJOBTDC(  IC)
       OJOBTDR      = OJOBTDR      + OJOBTDC(  IC)
C
C **************************************************************************
C                   ESTIMATE CAPITAL COST BY STATE/COUNTRY
C **************************************************************************
C CAPCOSC   = ORIGINALLY CAP COST ($TRIL) OF GENERATORS IN STATE/COUNTRY
C             UPDATED HERE TO BE CAPITAL COST OF EVERYTHING
C CAPNOTGEN = CAP COST ($TRIL) OF ALL NON-GENERATION (THUS STORAGE, HVDEC, H2)
C             PARTITION THIS BY STATE/COUNTRY BASED ON END-USE LOAD
C RATIOLOAD = WWSTOT/SUMWWS = RATIO END-USE LOAD IN STATE/COUNTRY TO THAT IN REGION
C COEANNM   = REGIONAL MEAN ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
C ANNCOSC   = STATE/COUNTRY MEAN ANNNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR) BY
C
       CAPCOSC(IC) = CAPCOSC(IC) + CAPNOTGEN * RATIOLOAD
       ANNCOSC(IC) = COEANNM * RATIOLOAD
      ENDDO
C     ENDDO I=1, NCOUNGRID(IGRIDUSE)
C
C TCONJOBR  = SUM OF TCONJOBC OVER ALL STATES/COUNTRIES IN A REGION
C TOPJOBR   = SUM OF TOPJOBC OVER ALL STATES/COUNTRIES IN A REGION
C TCREATE   = TOTAL LONG-TERM, FULL-TIME CONSTRUCTION+OPERATION JOBS W/WWS
C ANETJOB   = NET LONG-TERM, FULL-TIME JOBS MINUS LOST W/WWS
C AJOBLOSSR = SUM OF AJOBLOSSC OVER ALL STATES/COUNTRIES IN A REGION
C CJOBSTOR  = # REGIONAL LONG-TERM, FULL-TIME MANUF/CONSTRUC/DECOMIS STORAGE JOBS
C OJOBSTOR  = # REGIONAL LONG-TERM, FULL-TIME O&M STORAGE JOBS
C CJOBTDR   = REGIONAL LONG-TERM, FULL-TIME CONVENTL+HVDC MANUF/CONSTRUC TRANSMIS JOBS
C OJOBTDR   = REGIONAL LONG-TERM, FULL-TIME CONVENTL+HVDC O&M TRANSMIS JOBS
C SUMWWS    = SUM OF END-USE LOAD (GW) OVER ALL COUNTRIES IN DATASET
C ALLCAPC   = REGIONAL MEAN UP-FRONT CAPITAL COST ($TRILLION) OF
C             NEW WWS DEVICES + STORAGE + HVDC + H2 INFRASTRUCTURE
C COEANNM   = REGIONAL MEAN ANNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR)
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C BAULOADR  = REGION 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAUBILE   = $BIL/YEAR COST OF BAU ENERGY (ASSUMES ALL ENERGY SAME
C             COST/KWH AS ELECTRICITY)
C BAUBILH   = $BIL/YEAR HEALTH COST 2050 DUE TO BAU ENERGY
C BAUBILC   = $BIL/YEAR CLIMATE COST 2050 DUE TO BAU ENERGY
C BAUBILT   = $BIL/YEAR ENERGY+HEALTH+CLIM COST 2050 FROM BAU ENERGY
C AMORT50R  = 2050 AIR POL MORTALITY BY REGION IN ARRAY
C CO2E2050R = REGION TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C
      TCREATE = TCONJOBR + TOPJOBR
      ANETJOB = TCREATE  - AJOBLOSSR(IGRIDUSE)
      WRITE(IOUT,373) NAMEGRID(IGRIDUSE),NCOUNGRID(IGRIDUSE),
     1                TCONJOBR,TOPJOBR,TCREATE,AJOBLOSSR(IGRIDUSE),
     1                ANETJOB,CJOBSTOR,OJOBSTOR,CJOBTDR,OJOBTDR,
     1                SUMWWS(IGRIDUSE),ALLCAPC,COEANNM,
     1                BAULOADR(IGRIDUSE),BAUBILE,BAUBILH,BAUBILC,
     1                BAUBILT,AMORT50R(IGRIDUSE),
     1                CO2E2050R(IGRIDUSE)/1.0E+06
 373  FORMAT('REG ',A14,'#SUB ',I3,
     1'            CONSTJOBS    OPJOBS TOTNEWJOBS JOBSLOSS   NETJOBS  ',
     1     'CJOBSTOR OJOBSTOR    CJOBTD    OJOBTD WWSLOAD-GW ',
     1     'CAPCOS-$TRIL WWS-$BIL/Y BAULOAD-GW BAUEN-$BIL/Y  BAUMORT ',
     1     '   BAUCLIM     BAUTOT MORT2050 MILTON-CO2E/Y',/
     1       '      REGIONAL SUM ',19X,9(0PF10.0),8(0PF11.5),
     1       0PF10.0,0PF13.3)

C TCONJOBC  = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME CONSTRUCTION JOBS W/WWS
C             THESE ARE # OF 1-YEAR JOBS DIVIDED BY LIFETIME OF DEVICE
C             INCLUDES OF NEW DEVICES ONLY
C TOPJOBC   = STATE/COUNTRY TOTAL LONG-TERM, FULL-TIME OPERATION JOBS W/WWS
C             INCLUDES OF EXISTING PLUS NEW DEVICES
C TCREATE   = TOTAL LONG-TERM, FULL-TIME CONSTRUCTION+OPERATION JOBS W/WWS
C AJOBLOSSC = JOB LOSS IN STATE/COUNTRY, AS CALCULATED FROM SPREADSHEET
C ANETJOB   = NET LONG-TERM, FULL-TIME JOBS MINUS LOST W/WWS
C CJOBSTORC = # STATE/COUNTRY LONG-TERM, FULL-TIME MANUF/CONSTRUC/DECOMIS STORAGE JOBS
C OJOBSTORC = # STATE/COUNTRY LONG-TERM, FULL-TIME O&M STORAGE JOBS
C OJOBTDC   = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC O&M TRANSMIS JOBS
C CJOBTDC   = STATE/COUNTRY LONG-TERM, FULL-TIME CONVENTL+HVDC
C             MANUF/CONSTRUC TRANSMIS JOBS
C WWSTOT    = TOTAL 2050 END-USE LOAD (GW) FOR EACH 1..MXCOUNTRY COUNTRY
C CAPCOSC   = ORIGINALLY CAP COST ($TRIL) OF GENERATORS IN STATE/COUNTRY
C             FINAL: CAPITAL COST OF EVERYTHING BY STATE/COUNTRY
C ANNCOSC   = STATE/COUNTRY MEAN ANNNUAL TOTAL COST OF WWS ENERGY ($BILLION/YR) BY
C BAURATIO  = RATIO OF BAU LOAD IN STATE/COUNTRY TO THAT IN REGION OF
C             STATE/COUNTRY
C BAULOADC  = STATE/COUNTRY 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAUEC     = STATE/COUNTRY $BIL/YEAR COST OF BAU ENERGY (ASSUMES ALL ENERGY SAME
C             COST/KWH AS ELECTRICITY)
C BAUHC     = STATE/COUNTRY $BIL/YEAR HEALTH COST 2050 DUE TO BAU ENERGY
C BAUCC     = STATE/COUNTRY $BIL/YEAR CLIMATE COST 2050 DUE TO BAU ENERGY
C BAUTC     = STATE/COUNTRY $BIL/YEAR ENERGY+HEALTH+CLIM COST 2050 FROM BAU ENERGY
C AMORT50C  = 2050 AIR POL MORTALITY BY STATE/COUNTRY
C CO2E2050C = STATE/COUNTRY TONNES-CO2E (CO2-EQUIVALENT)/YR EMISSIONS IN 2050
C BAULOADC  = STATE/COUNTRY 2050 BAU ANNUAL AVG LOAD FOR EVERYTHING (GW)
C BAULCOEC  = STATE/COUNTRY 2050 BAU LCOE ($2013) CENTS/KWH FOR RETAIL ELEC SECTOR
C BAUHEALC  = STATE/COUNTRY 2050 BAU AIR POLL HEALTH COST ($2013 CENTS/KWH-ALL-ENERGY)
C BAUCLIMC  = STATE/COUNTRY 2050 BAU CLIM COST ($2013 CENTS/KWH-ALL-ENERGY) IN
C BAUBILE   = $BIL/YEAR COST OF BAU ENERGY (ASSUMES ALL ENERGY SAME
C             COST/KWH AS ELECTRICITY)
C BAUBILH   = $BIL/YEAR HEALTH COST 2050 DUE TO BAU ENERGY
C BAUBILC   = $BIL/YEAR CLIMATE COST 2050 DUE TO BAU ENERGY
C BAUBILT   = $BIL/YEAR ENERGY+HEALTH+CLIM COST 2050 FROM BAU ENERGY
C CVER3     = MULTIPLY BY CVER3 TO CONVERT CENTS-TWH/KWH TO $BILLION =
C           = 10^-11 $BILLION/CENTS x 10^9 KWH/TWH
C AVHRSPYR  = 8760 HOURS PER YEAR IN NON-LEAP YEARS
C
      DO I     = 1, NCOUNGRID(IGRIDUSE)
       IC      = NUMCOUNGR(IGRIDUSE,I)
       TCREATE = TCONJOBC(IC) + TOPJOBC(IC)
       ANETJOB = TCREATE      - AJOBLOSSC(IC)
C
C WANT STATE/COUNTRY ANNUAL BAU ENERGY COST TO REFLECT REGIONAL RATHER
C STATE/COUNTRY COST BUT WANT HEALTH AND CLIMATE COST TO REFLECT
C STATE/COUNTRY
C
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       BAUTWHY  = BAULOADC(IC) * AVHRSPYR / GWPTW
       BAURATIO = BAULOADC(IC) / BAULOADR(IGRIDUSE)
       BAUEC    = BAUBILE * BAURATIO
C      BAUHC    = BAUBILH * BAURATIO
C      BAUCC    = BAUBILC * BAURATIO
C      BAUEC    = BAULCOEC(IC) * BAUTWHY * CVER3
       BAUHC    = BAUHEALC(IC) * BAUTWHY * CVER3
       BAUCC    = BAUCLIMC(IC) * BAUTWHY * CVER3
       BAUTC    = BAUEC + BAUHC + BAUCC
C
       WRITE(IOUT,374)I, NAMCOUNGR(IGRIDUSE,I), IC,
     1               TCONJOBC(IC),TOPJOBC(IC),TCREATE,AJOBLOSSC(IC),
     1               ANETJOB,CJOBSTORC(IC),OJOBSTORC(IC),
     1               CJOBTDC(IC),OJOBTDC(IC),WWSTOT(IC),CAPCOSC(IC),
     1               ANNCOSC(IC),BAULOADC(IC),BAUEC,BAUHC,BAUCC,BAUTC,
     1               AMORT50C(IC),CO2E2050C(IC)/1.0E+06
 374   FORMAT('   SUB-REGION   ',I3,1X,A14,1X,I3,9(0PF10.0),8(0PF11.5)
     1        0PF10.0,0PF11.3)
       ENDDO
C      ENDDO I=1, NCOUNGRID(IGRIDUSE)
       WRITE(IOUT,*)
C
C ***************************************************************************
C                    PRINT TOTAL LOADS BY SECTOR
C ***************************************************************************
C
       WRITE(IOUT,284) TORIGLD, BLOADRES * HRSPYR, BLOADCOM * HRSPYR,
     1                          BLOADIND * HRSPYR, BLOADTRA * HRSPYR,
     1                          BLOADAGF * HRSPYR, BLOADOTH * HRSPYR,
     1                          TLOADINFX* HRSPYR, TLOADFLEX* HRSPYR
C
C PRINT ENERGY OUTPUT BE DEVICE (TWH) AFTER T&D LOSSES. THIS IS BEFORE
C LOSSES TO/FROM STORAGE AND BEFORE CURTAILMENT. THE ONLY LOSS IS T&D
C
       WRITE(IOUT,288) TWHONWIN, TWHOFFWIN, TWHROOFPV, TWHUTILPV,
     1                 TWHCSP +  TWHSTCSP,  TWHHYD,    TWHWAV,
     1                 TWHGEOEL, TWHTID,    TWHTHEAT,  TWHGEOHT
C
C TWHH2TR   = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR TRANSPORT
C TWHH2IN   = TWH/YR ELEC TO PRODUCE H2+LEAKS+ELECTROLYSIS+COMPRESS FOR INDUSTRY
C
C TREMCSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM CSP STORAGE DURING SIM
C TREMPSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM PHS STORAGE DURING SIM
C TREMFSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM H2FC DURING SIM
C TREMBSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM BATTERIES DURING SIM
C TREMOSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM CW-STES+PCM-ICE DURING SIM
C TREMHSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM HW-STES DURING SIM
C TDISCHBAT = TOTAL EN (TWH) (INCLUDING LOSSES) REMOVED FROM BAT DURING SIM
C FINSTOR   = NET ENERGY (TWH) (NOT LOSSES) IN STORAGE AT END OF SIMULATION
C             AFTER DISCHARGE LOSS REMOVED
C FINEFFIC  = RESULTING ROUND-TRIP STORAGE EFFICIENCY (%) OF ACTUAL SYSTEM
C           = ENERGY DISCHARGED+LOSSES DURING DISCHARGE
C           + ENERGY DIF BETWEEN BEGIN AND END, ALL DIVIDED BY
C             ENERGY DISCHARGED+LOSSES DURING CHARGE+DISCHARGE+DIF BET BEG+END
C TSUMCSTOR = NET CHANGE IN CSP STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) CSP STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMPSTOR = NET CHANGE IN PHS STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) PHS STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMBSTOR = NET CHANGE IN BATTERY STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMOSTOR = NET CHANGE IN CW-STES + PCM-ICE STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMHSTOR = NET CHANGE IN HW-STES  STORAGE (TWH) OVER SIMULATION
C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMBRSTO = NET CHANGE IN HI-T BRICK STORAGE (TWH) OVER SIMULATION
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C           = NET CHANGE ENERGY ADDED TO (+) SUBTRACTED FROM (-) STORAGE
C             EACH MONTH MINUS THE ENERGY LOSS COMING OUT OF STORAGE
C           = STORAGE AT END OF SIMULATION MINUS THAT AT BEGINNING
C TSUMCSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING CSP STORAGE
C TSUMPSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING PHS STORAGE
C TSUMBSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING BATTERY STORAGE
C TSUMOSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING CW-STES+PCM-ICE
C TSUMHSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING HW-STES STORAGE
C TSUMBRSTL = TWH LOSS DURING CHARGING+DISCHARGING+STORING HI-T BRICK STORAGE
C TSUMUGSTL = TWH LOSS DURING CHARGING+DISCHARGING+STORING UTES STORAGE
C
C CSP STORAGE
C  TREMCSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM CSP STORAGE DURING SIM
C  CFCSP     = CAPACITY FACTOR (FRAC) OF CSP STORAGE
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFCSP    = TREMCSTOR / (CSPCHSTO * TSUMHRS + SMAL30)
      DELCSTOR = TSUMCSTOR + TSUMCSTLS - TSUMCSTLI
      FINCSTOR = DELCSTOR * RTCSPEFF
      FINEFFIC = PCT * (TREMCSTOR + FINCSTOR)
     1         /       (TREMCSTOR + DELCSTOR + TSUMCSTLS + SMAL30)
      WRITE(IOUT,289) TSUMCSTLS,TREMCSTOR,FINEFFIC,PCT*EFFCSP,CFCSP
C
C PHS STORAGE
C  TREMPSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM PHS STORAGE DURING SIM
C  CFPHS     = CAPACITY FACTOR (FRAC) OF PHS STORAGE
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFPHS    = TREMPSTOR / (TSTORPHS * TSUMHRS + SMAL30)
      DELPSTOR = TSUMPSTOR + TSUMPSTLS - TSUMPSTLI
      FINPSTOR = DELPSTOR * RTPHSEFF
      FINEFFIC = PCT * (TREMPSTOR + FINPSTOR)
     1         /       (TREMPSTOR + DELPSTOR + TSUMPSTLS + SMAL30)
      WRITE(IOUT,292) TSUMPSTLS,TREMPSTOR,FINEFFIC,PCT*EFFPHS,CFPHS
C
C HYDROGEN STORAGE FOR ELECTRICITY
C  TREMFSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM H2FC DURING SIM
C  EFFH2CD   = ROUND-TRIP EFFICIENCY OF STORING ELECTRICITY IN H2 FOR USE
C              IN FUEL CELLS. INCLUDES ELECTROLYZER, COMPRESSOR, FUEL
C  CFH2GRID = CAPACITY FACTOR (FRAC) OF GRID HYDROGEN STORAGE
C           = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C             CELL EFFIC, ETC.
C
      CFH2GRID = TREMFSTOR / (H2SDISCH * TSUMHRS + SMAL30)
      DELFSTOR = TSUMFSTOR + TSUMFSTLS - TSUMFSTLI
      FINFSTOR = DELFSTOR * EFFH2CD
      FINEFFIC = PCT * (TREMFSTOR + FINFSTOR)
     1         /       (TREMFSTOR + DELFSTOR + TSUMFSTLS + SMAL30)
      WRITE(IOUT,293) TSUMFSTLS,TREMFSTOR,FINEFFIC,PCT*EFFH2CD,CFH2GRID
C
C HYDROPOWER STORAGE
C  BASEHYD   = 2050 HYDRO OUTPUT FROM TURBINE BEFORE T&D USED FOR BASELOAD POWER (TW)
C            = CONSTANT CHARGE AND DISCHARGE RATE (TW) OF HYDRO FOR BASELOAD
C  PKHYDISCH = MAX DISCHARGE RATE HYDRO FOR PEAKING POWER ALONE (TW) BEFORE T&D
C            = HYDISCHTW - BASEHYD
C  HYDISCHTW = MAX TOTAL DISCHARGE RATE OF HYDROELECTRIC POWER (TW)
C              USED FOR BOTH BASELOAD AND PEAKING
C            = INITIAL NAMEPLATE CAPACITY (DISHPINIT) * HPTURBRAT
C  TWHHYD    = CUMULATIVE TWH TOTAL HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C  TWHPKHYD  = CUMULATIVE TWH PEAK  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C  TWHBSHYD  = CUMULATIVE TWH BASE  HYDRO PRODUCED DURING SIM (AFTER T&D LOSSES)
C  CFHYD     = CAPACITY FACTOR (FRAC) OF TOTAL HYDROPOWER
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C  CFPKHYD   = CAPACITY FACTOR (FRAC) OF HYDROPOWER FOR PEAKING
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C  CFBSHYD   = CAPACITY FACTOR (FRAC) OF HYDROPOWER FOR BASELOAD
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFHYD    = TWHHYD   / (HYDISCHTW * TSUMHRS + SMAL30)
      CFBSHYD  = TWHBSHYD / (BASEHYD   * TSUMHRS + SMAL30)
      CFPKHYD  = TWHPKHYD / (PKHYDISCH * TSUMHRS + SMAL30)
      DELFSTOR = TSUMFSTOR + TSUMFSTLS - TSUMFSTLI
      WRITE(IOUT,597) 0.,TWHHYD,  0.,0.,CFHYD
      WRITE(IOUT,599) 0.,TWHBSHYD,0.,0.,CFBSHYD
      WRITE(IOUT,598) 0.,TWHPKHYD,0.,0.,CFPKHYD
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C
C COLD & ICE STORAGE (CW-STES + PCM-ICE)
C  TREMOSTOR = NET EN (TWH) (NOT LOSSES) REM FROM CW-STES + PCM-ICE DURING SIM
C  CFCOOL    = CAPACITY FACTOR (FRAC) OF CW-STES PLUS ICE STORAGE
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFCOOL   = TREMOSTOR / (TSTORCOOL * TSUMHRS + SMAL30)
      DELOSTOR = TSUMOSTOR + TSUMOSTLS - TSUMOSTLI
      FINOSTOR = DELOSTOR * RTCOLDEF
      FINEFFIC = PCT * (TREMOSTOR + FINOSTOR)
     1         /       (TREMOSTOR + DELOSTOR + TSUMOSTLS + SMAL30)
      WRITE(IOUT,290) TSUMOSTLS,TREMOSTOR,FINEFFIC,PCT*EFFCOLD,CFCOOL
C
C HOT WATER STORAGE (HW-STES)
C  TREMHSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM HW-STES DURING SIM
C  HOTDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF HOT WATER (HW)-STES
C  CFHWSTES  = CAPACITY FACTOR (FRAC) OF HW-STES STORAGE
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFHWSTES = TREMHSTOR / (HOTDISCH * TSUMHRS + SMAL30)
      DELHSTOR = TSUMHSTOR + TSUMHSTLS - TSUMHSTLI
      FINHSTOR = DELHSTOR * RTHTESEF
      FINEFFIC = PCT * (TREMHSTOR + FINHSTOR)
     1         /       (TREMHSTOR + DELHSTOR + TSUMHSTLS + SMAL30)
      WRITE(IOUT,295) TSUMHSTLS,TREMHSTOR,FINEFFIC,PCT*EFFHSTES,CFHWSTES
C
C HI-T BRICK HEAT STORAGE FOR INDUSTRY
C  TBRICKTWH = CUM ENERGY (TWH) OVER SIM SUPPLIED FOR HI-T INDUSTRIAL HEATING FROM
C              BRICK STORAGE. DOES NOT INCLUDED LOSSES. JUST SUPPLIES
C  TSUMBRSTL = TWH LOSS DURING CHARGING+DISCHARGING+STORING BRICK IND HEAT STORAGE
C  HBTDISCH  = MAX DISCHARGE RATE (TW-TH) OF FIREBRICK BATTERIES
C  TSUMHRS  = NUMBER OF HOURS OF SIMULATION THAT DATA HAVE BEEN ACCUMULATED FOR
C  CFBRICK  = CAPACITY FACTOR (FRAC) OF HI-T BRICK STORAGE FOR INDUSTRY
C           = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFBRICK  = TBRICKTWH / (HBTDISCH * TSUMHRS + SMAL30)
      DELBRSTO = TSUMBRSTO + TSUMBRSTL - TSUMBRSTI
      FINBRSTO = DELBRSTO * RTHBTEFF
      FINEFFIC = PCT * (TBRICKTWH + FINBRSTO)
     1         /       (TBRICKTWH + DELBRSTO + TSUMBRSTL + SMAL30)
      WRITE(IOUT,296) TSUMBRSTL,TBRICKTWH,FINEFFIC,PCT*EFFHTBAT,CFBRICK
C
C UNDERGROUND THERMAL ENERGY STORAGE
C  CFUTES    = CAPACITY FACTOR (FRAC) OF UNDERGROUND THERMAL EN STORAGE
C            = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C  UTESDISCH = MAX DISCHARGE RATE (TW) UNDERGROUND SEASONAL HEAT STORAGE
C  TREMUSTOR = NET EN (TWH) (NOT LOSSES) REM FROM UTES
C
      IF (UTESDISCH.GT.0.) THEN
       CFUTES  = TREMUSTOR / (UTESDISCH * TSUMHRS + SMAL30)
      ELSE
       CFUTES  = 0.
      ENDIF
      DELUGSTO = TSUMBRSTO + TSUMUGSTL - TSUMUGSTI
      FINUGSTO = DELUGSTO * RTUGEFF
      FINEFFIC = PCT * (TREMUSTOR + FINUGSTO)
     1         /       (TREMUSTOR + DELUGSTO + TSUMUGSTL + SMAL30)
      WRITE(IOUT,297) TSUMUGSTL,TREMUSTOR,FINEFFIC,PCT*EFFUTES,CFUTES
C
C BATTERY STORAGE
C  STORBTWH  = MAX STORAGE CAPACITY (TWH) OF BATTERY STORAGE
C  TREMBSTOR = NET EN (TWH) (NOT LOSSES) DISCHARGED FROM BATTERIES DURING SIM
C  TSUMBSTLS = TWH LOSS DURING CHARGING+DISCHARGING+STORING BATTERY STORAGE
C  TDISCHBAT = TOTAL EN (TWH) (INCLUDING LOSSES) REMOVED FROM BAT DURING SIM
C            = TREMBSTOR + TSUMBSTLS - TSUMBSTLI
C  CYCLES    = # OF CYCLES (TIMES THAT BATTERY FULLY DISCHARGES) DURING SIM
C  CYCPDAY   = NUMBER OF CYCLES PER DAY
C  CYCPYR    = NUMBER OF CYCLES PER YEAR
C  HRSSIM    = NUMBER OF HOURS OF SIMULATION (HOURS)
C  MXHPDAY   = NUMBER OF HOURS PER DAY (24)
C  MXDAYYR   = MAX NUMBER OF DAYS PER YEAR (366, TO ACCOUNT FOR LEAP YEARS)
C  DEFBLIFE  = DEFAULT BATTERY LIFE (YR) AT 1 CYCLE PER DAY
C  BATLIFE   = BATTERY LIFE (YR) AT ACTUAL # CYCLES PER DAY
C              ASSUMES 1 CYCLE/DAY GIVES 10 YEAR LIFE
C  BATMXOUT  = MAX DISCHARGE RATE (TW) FROM BATTERY STORAGE (INCLUDING LOSSES)
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C  BATDISCH  = MAX DISCHARGE AND CHARGE RATE (TW) OF BATTERIES
C  STORHBAT  = MAX HOURS BATTERY STORAGE AT MAX DISCHARGE RATE
C  HRMAXBAT  = MAX HOURS OF STORAGE NEEDED AT MAX BATTERY DISCHARGE
C              RATE (BATMXOUT) TO ENSURE ENOUGH CAPACITY (STORBTWH)
C              IF HRMAXBAT > STORHBAT, THEN CAN CHANGE STORHBAT=HRMAXBAT
C              AND REDUCE BATDISCH TO BATMXOUT
C
      DEFBLIFE = 10.
      IF (STORBTWH.GT.0.AND.BATMXOUT.GT.0.) THEN
       HRMAXBAT = STORBTWH / BATMXOUT
       CYCLES   = TDISCHBAT / STORBTWH
       CYCPDAY  = CYCLES * MXHPDAY / HRSSIM
       CYCPYR   = CYCPDAY * 365.25
       BATLIFE  = DEFBLIFE / CYCPDAY
      ELSE
       HRMAXBAT = 0.
       CYCLES   = 0.
       CYCPDAY  = 0.
       CYCPYR   = 0.
       BATLIFE  = 0.
      ENDIF
C
C  CFBAT    = CAPACITY FACTOR (FRAC) OF GRID BATTERY STORAGE
C           = ENERGY OUTPUT (NOT LOSSES) FROM STORAGE OVER SIM / MAX POSS OUTPUT
C
      CFBAT    = TREMBSTOR / (BATDISCH * TSUMHRS + SMAL30)
      DELBSTOR = TSUMBSTOR + TSUMBSTLS - TSUMBSTLI
      FINBSTOR = DELBSTOR * RTBATEFF
      FINEFFIC = PCT * (TREMBSTOR + FINBSTOR)
     1         /       (TREMBSTOR + DELBSTOR + TSUMBSTLS + SMAL30)
      WRITE(IOUT,291) TSUMBSTLS, TREMBSTOR, FINEFFIC, PCT*EFFBAT,
     1                CYCLES, CYCPDAY, CYCPYR, BATLIFE, HRMAXBAT,
     1                BATMXOUT,CFBAT
C
      CLOSE(KMON)
C
C ***************************************************************************
C                     PRINT CAPITAL COSTS AND LCOES
C ***************************************************************************
C FRCH2ALL = FRAC OF ALL-SECTOR 2050 LOAD USED TO PRODUCE/COMPRESS/STORE H2
C DECOMISL = WEIGHTED AVG LOW  DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C DECOMISM = WEIGHTED AVG MEAN DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C DECOMISH = WEIGHTED AVG HIGH DECOMMISS COST AS FRACTION OF OVERNIGHT CAP COST
C HVDCKM   = KM OF HVDC LINES NEEDED
C HVDCJOBC = HVDC CONSTRUCTION JOBS/YR OVER REGION
C HVDCJOBO = HVDC OPERATIONN JOBS/YR OVER REGION
C CAPLINE  = NAMEPLATE CAPACITY OF LINE (MW)
C HVDCLINC = HVDC LINE COST ($/MWtr-KM)
C FLDISELEC= FRAC OF ALL END-USE ELEC SUBJECT TO HVDC LONG-DIST TRAN
C
      WRITE(IOUT,302) HVDCKM, CAPLINE, HVDCLINC, FLDISELEC,
     1                HVDCJOBC, HVDCJOBO
      WRITE(IOUT,282) TENUSED
      WRITE(IOUT,283) DISCOUNTL*PCT, DISCOUNTM*PCT, DISCOUNTH*PCT,
     1                STORLIFEL,     STORLIFEM,     STORLIFEH,
     1                STORLIFBL,     STORLIFBM,     STORLIFBH,
     1                STORLIFHBL,    STORLIFHBM,    STORLIFHBH,
     1                OPMAINTL *PCT, OPMAINTM *PCT, OPMAINTH *PCT,
     1                DECOMISL *PCT, DECOMISM *PCT, DECOMISH *PCT,
C
C CAPITAL COST ($TRIL) FOR ELECTRICITY GENERATORS
C
     1                TRILLO,    TRILMN,   TRILHI,
C
C CAPITAL COST ($TRIL) FOR HEAT GENERATORS
C
     1                TRILHLO,   TRILHMN,  TRILHHI,
C
C CAPITAL COST ($TRIL) FOR LI-BATTERY STORAGE
C
     1                TRILBATL, TRILBATM, TRILBATH,
C
C CAPITAL COST ($TRIL) FOR H2 GRID ELEC STORAGE
C   INCLUDES COSTS OF ELECTROLYZER, COMPRESSOR, RECTIFIER, STORAGE, FUEL CELL
C
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     1                CAPGRH2L, CAPGRH2M, CAPGRH2H,
C
C CAPITAL COST ($TRIL) FOR NON-BATTERY, NON-H2  ELECTRICITY STORAGE
C
     1                TRILSTORL, TRILSTORM,TRILSTORH,
C
C CAPITAL COST ($TRIL) FOR HEAT STORAGE
C
     1                TRILHTSTL, TRILHTSTM,TRILHTSTH,
C
C CAPITAL COST ($TRIL) FOR COLD STORAGE
C
     1                TRILCLSTL, TRILCLSTM,TRILCLSTH,
C
C CAPITAL COST ($TRIL) FOR ADDITIONAL HYDROPOWER TURBINES
C
     1                TRILADHPL, TRILADHPM,TRILADHPH,
C
C CAPITAL COST ($TRIL) FOR UTES STORAGE
C
     1                TRILUGSTL, TRILUGSTM,TRILUGSTH,
C
C CAPITAL COST ($TRIL) FOR HEAT PUMPS FOR HW/CW-STES+UTES STORAGE
C
     1                TRILSHPL, TRILSHPM,TRILSHPH,
C
C CAPITAL COST ($TRIL) FOR BRICK INDUSTRIAL HEAT STORAGE
C
     1                TRILHBTL, TRILHBTM, TRILHBTH,
C
C CAPITAL COST ($TRIL) FOR HVDC LONG-DISTANCE TRANSMMISSION
C
     1                CAPHVDCL,  CAPHVDCM, CAPHVDCH,
C
C CAPITAL COST ($TRIL) FOR NON-GRID H2 ELECTROLYSIS/COMPRESSION/STORAGE
C
     1                CAPH2L,    CAPH2M,   CAPH2H,
C
C CAPITAL COST ($TRIL) FOR EVERYTHING (ELEC AND HEAT GENERATION, HEAT/COLD
C STORAGE, HYDROPOWER TURBINES, UTES STORAGE, AND SHORT-DIST T&D
C (INCLUDED IN GENERATION. DOESN'T INCLUDE LONG-DIST TRANSMISSION OR
C NON-GRID-H2 OR GRID-H2, WHICH ARE ALL INCLUDED IN LCOE AND IN CAPITAL COST
C
     1                TRILTOTL + CAPHVDCL + CAPH2L + CAPGRH2L,
     1                TRILTOTM + CAPHVDCM + CAPH2M + CAPGRH2M,
     1                TRILTOTH + CAPHVDCH + CAPH2H + CAPGRH2H,
C
C ANNUAL TOTAL COST OF ENERGY ($BILLION/YR)
C
     1                COEANNL,   COEANNM,   COEANNH,
C
C COST (CENTS/KWH) OF SHORT-DISTANCE TRANSMISSION
C
     1                SDTRANSL,  SDTRANSM, SDTRANSH,
C
C COST (CENTS/KWH) OF LONG-DISTANCE TRANSMISSION
C
     1                TRCOSTLO,  TRCOSTMN, TRCOSTHI,
C
C COST (CENTS/KWH) OF DISTRIBUTION
C
     1                DISTRIBL,  DISTRIBM, DISTRIBH,
C
C COST (CENTS/KWH) OF ELECTRIC POWER GENERATION ONLY (PER KWH ALL ELEC+HEAT)
C
     1                COSTPOWL,  COSTPOWM, COSTPOWH,
C
C COST (CENTS/KWH) OF ADDITIONAL TURBINES FOR FASTER DISCHARGE CONVENTIONAL HYDRO
C
     1                COSTHPTL,  COSTHPTM, COSTHPTH,
C
C COST (CENTS/KWH) OF SOLAR + GEOTHERMAL HEAT GENERATION
C
     1                COSTHTL,   COSTHTM,  COSTHTH,
C
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C COST (CENTS/KWH) OF LI-BATTERY STORAGE
C
     1                COSTBATL,  COSTBATM, COSTBATH,
C
C COST (CENTS/KWH) OF H2 STORAGE FOR GRID ELECTRICITY
C   INCLUDES COSTS OF ELECTROLYZER, COMPRESSOR, RECTIFIER, STORAGE, FUEL CELL
C
     1                COSTH2EL,  COSTH2EM, COSTH2EH,
C
C COST (CENTS/KWH) OF CSP-PCM + PHS STORAGE
C
     1                COSTSTOL,  COSTSTOM, COSTSTOH,
C
C COST (CENTS/KWH) OF CW-STES + PCM-ICE STORAGE
C
     1                COSTSCLL,  COSTSCLM, COSTSCLH,
C
C COST (CENTS/KWH) OF HW-STES STORAGE
C
     1                COSTSHTL,  COSTSHTM, COSTSHTH,
C
C COST (CENTS/KWH) OF UTES STORAGE
C
     1                COSTUGSL,  COSTUGSM, COSTUGSH,
C
C COST (CENTS/KWH) OF HEAT PUMPS FOR HW/CW-STES + UTES STORAGE
C
     1                COSTSHPL,  COSTSHPM, COSTSHPH,
C
C COST (CENTS/KWH) OF BRICK INDUSTRIAL HEAT BATTERY  STORAGE
C
     1                COSTHBTL,  COSTHBTM, COSTHBTH,
C
C COST (CENTS/KWH) TO PRODUCE/COMPRESS/STORE NON-GRID H2
C
     1                H2COSTLO,  H2COSTMN, H2COSTHI,
C
C COST (CENTS/KWH) OF ALL NON-H2 STORAGE, INCLUDING EXTRA HYDRO TURBINES
C                   AND HEAT PUMPS FOR HW/CW-STES+UTES STORAGE
C                   AND INDUSTRIAL FIREBRICK STORAGE
C
     1  COSTBATL+COSTSTOL+COSTSHTL+COSTSCLL+COSTHPTL+COSTUGSL+COSTSHPL
     1 +COSTHBTL,
     1  COSTBATM+COSTSTOM+COSTSHTM+COSTSCLM+COSTHPTM+COSTUGSM+COSTSHPM
     1 +COSTHBTM,
     1  COSTBATH+COSTSTOH+COSTSHTH+COSTSCLH+COSTHPTH+COSTUGSH+COSTSHPH
     1 +COSTHBTH,
C
C COST (CENTS/KWH) ALL ELEC+HEAT GENERATION + SHORT-DISTANCE T&D + ALL STORAGE
C      (ASIDE FROM GRID OR NONGRID H2 STORAGE) + HEAT PUMPS TO FEED
C      HW/CW-STES+UTESE
C
     1                COSTENL,   COSTENM,  COSTENH,
C
C THIS IS COST OF ELECTRICITY-SECTOR ONLY ELECTRICITY
C (COST OF POWER+COST OF SOLAR+GEO HT+CSP-PCM+PHS+LI-BAT+CW-STES+SHORT-DIST T&D
C PLUS LONG DISTANCE T&D NOT ASSOCIATED WITH NON-GRID H2 PRODUCTION)
C INCLUDE COST OF SOLAR+GEO HEAT TO ENSURE AL ENERGY GENERATED IN THE DENOMINATOR
C OF COST/KWH IS ACCOUNTED FOR. OTHERWISE, NEED TO DIVIDE BY ONLY ELECTRIC
C ENERGY PRODUCED RATHER THAN ALL ENERGY PRODUCED.
C DON'T INCLUDE COST OF HEAT STORAGE (HW/CW-STES, UTES), HEAT PUMPS FOR
C HEAT STORAGE, H2, OR PORTION OF LONG DISTANCE TRANSMISSION ASSOCIATED WITH H2
C
     1  COSTPOWL+COSTHTL+COSTBATL+COSTSTOL+COSTSCLL+COSTHPTL
     1          +TRCOSTLO*(1.-FRCH2ALL)+SDTRANSL+DISTRIBL+COSTH2EL,
     1  COSTPOWM+COSTHTM+COSTBATM+COSTSTOM+COSTSCLM+COSTHPTM
     1          +TRCOSTMN*(1.-FRCH2ALL)+SDTRANSM+DISTRIBM+COSTH2EM,
     1  COSTPOWH+COSTHTH+COSTBATH+COSTSTOH+COSTSCLH+COSTHPTH
     1          +TRCOSTHI*(1.-FRCH2ALL)+SDTRANSH+DISTRIBH+COSTH2EH,
C
C THIS IS COST OF ALL-SECTOR ENERGY (WHICH IS ALL ELECTRICITY)
C (COST OF POWER + ALL-STORAGE + ALL SHORT & LONG-DISTANCE TRANSMISSION
C      + ALL H2 + HEAT PUMPS FOR HOT STORAGE
C
     1                COEPKWHL,  COEPKWHM, COEPKWHH
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C
C ***************************************************************************
C                            FORMATS
C ***************************************************************************
C
 254  FORMAT('SIMTOT TWH ELEC (NOT FOR STOR) LOAD = ',(1PE11.4)/,
     1       '       TWH HEAT STORAGE LOAD        = ',(1PE11.4)/,
     1       '       TWH COLD STORAGE LOAD        = ',(1PE11.4)/,
     1       '       TWH HI-T STORAGE LOAD        = ',(1PE11.4)/,
     1       '       TWH H2   STORAGE LOAD        = ',(1PE11.4)/,
     1       '       TWH TOTAL        LOAD        = ',(1PE11.4)/,
     1       '       TWH ALL LOSSES               = ',(1PE11.4)/,
     1       '       TWH SUPPLY                   = ',(1PE11.4)/,
     1       '       TWH T&D LOSSES               = ',(1PE11.4)/,
     1       '       TWH CHANGSTOR                = ',(1PE11.4)/,
     1       '       TWH DEM+LOSSES-SUPPLY        = ',(1PE11.4)/)
 255  FORMAT('CAPACITY FACTOR BEFORE T&D LOSSES '/,
     1       'ONSHORE WIND                     = ',1(0PF13.5)/,
     1       'OFFSHORE WIND                    = ',1(0PF13.5)/,
     1       'ROOFTOP PV                       = ',1(0PF13.5)/,
     1       'UTILITY PV                       = ',1(0PF13.5)/,
     1       'CSP (INCLUDING STORED CSP)       = ',1(0PF13.5)/,
     1       'GEOTHERMAL ELECTRICITY           = ',1(0PF13.5)/,
     1       'HYDROELECTRIC                    = ',1(0PF13.5)/,
     1       'WAVE                             = ',1(0PF13.5)/,
     1       'TIDAL                            = ',1(0PF13.5)/,
     1       'SOLAR THERMAL                    = ',1(0PF13.5)/,
     1       'GEOTHERMAL HEAT                  = ',1(0PF13.5)/,
     1       'HYDRO ESTIMATE BEFORE SIMULATION = ',1(0PF13.5)/)
 257  FORMAT('MAX%-H2EN-STORED H2CURMAX FRCH2STOR ',3(0PF12.5)/)
 258  FORMAT('MAX FROM STORAGE AS % OF TW MAX SUPPLY + MAX SUPPLY ',
     1        2(0PF12.5)/)
 259  FORMAT('MAX TO STORAGE AS PERCENT OF TW MAX SUPPLY ',0PF12.5/)
 260  FORMAT('MAX POWER (TW) TAKEN FROM, ADDED TO STORAGE ',2(0PF12.5)/)
 361  FORMAT('% H2-GRID-STORAGE FILLED, STORH2MX H2STORMX ',3(0PF12.5)/)
 362  FORMAT('% H2-GRID-STORAGE FILLED, STORH2MX STORFTWH ',3(0PF12.5)/)
 261  FORMAT('X ',A8,A5,' INFLXLD-TWH FLXLOAD     H2LOAD      FLX+H2LD',
     1   '    TOTLOAD     ORIGLOAD   LOSS_IN_STOR ALLSTORLOSS D-STORAG',
     1   '    LOSS_INUG_STO ALL_UG_LOSS D-UGSTOR  D-H2STORAGE ',
     1   'CURT LOAD+TDSTORLS+CURT SUPBEFT&D   WIND-ON+OFF SOL-PV+CSP  ',
     1   'HYDRO       WAV+GEO+TID SOL-HEAT    GEO-HEAT    TDLOSS      ',
     1   'SUPAFTT&D   COLDLOAD    WARMLOAD    #HRS')
 262  FORMAT(A1,1X,0PF9.3,1X,I2,2X,16(1X,0PF13.6),1(1X,0PF13.6),
     1       7(1X,0PF13.6),2(1X,0PF13.6),1X,0PF13.6)
 263  FORMAT('STORCINIT TSUMCSTOR STORCCUR STORCINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 264  FORMAT('STORPINIT TSUMPSTOR STORPCUR STORPINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 267  FORMAT('STORBINIT TSUMBSTOR STORBCUR STORBINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 270  FORMAT('STORFINIT TSUMFSTOR STORFCUR STORFINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 273  FORMAT('STOROINIT TSUMOSTOR STOROCUR STOROINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 274  FORMAT('STORHINIT TSUMHSTOR STORHCUR STORHINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 275  FORMAT('UGSTINIT TSUMUGSTO UGSTORC UGSTINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 588  FORMAT('BRICKNIT TSUMBRSTO BRSTORC BRICKINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 276  FORMAT('H2STINIT TSUMH2STO H2STORC H2STINIT+ADD-TWH=',/
     1       4(0PF12.5)/)
 277  FORMAT('HYDROINIT HYDROFIN-TWH PKHYDMAX HYDTWHMAX (BEF T&D)=',/
     1       4(0PF12.5)/)
 265  FORMAT('TWH-TSUMLOAD+TSUMFLXLD+TSUMH2LD+REMAINDEM ',
     1       'TSUMLOAD TSUMFLXLD TSUMH2LD',/4(0PF12.5),/
     1       'REMAINDEM TLOADALL TLOADFLX TLOADALL-TLOADFLX ANYREMAIN',/
     1        5(0PF12.5)/)
 282  FORMAT('END-ENERGY-GENERATED(TWH/Y) ',1(0PF12.5),/)
 283  FORMAT('DISCOUNT RATE             (%)     LO MN HI= ',3(0PF12.5)/,
     1       'NONBAT STORAGE LIFETIME   (YEARS) LO MN HI= ',3(0PF12.5)/,
     1       'BATTERY STORAGE LIFETIME  (YEARS) LO MN HI= ',3(0PF12.5)/,
     1       'IND FIREBRICK STOR LIFE   (YEARS) LO MN HI= ',3(0PF12.5)/,
     1       'STOR O&M AS % OF CAP COST (%/YR)  LO MN HI= ',3(0PF12.5)/,
     1       'DECOMMISS % CAP COST      (%/YR)  LO MN HI= ',3(0PF12.5)/,
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     1       'CAP COST ELEC GENERATORS  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST HEAT GENERATORS  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST LI-BAT STORAGE   ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST H2 ELEC STORAGE  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST CSPPCM+PHS STOR  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST HWSTES STORAGE   ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST CWSTES+ICE STOR  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST ADDED HYDRO TURB ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST UTES STORAGE     ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST HEATPUMP FOR STOR($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST BRICK IND HT STOR($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST LONG-DIST TRANS  ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST H2PROD/COMP/STOR ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'CAP COST EVERYTHING       ($TRIL) LO MN HI= ',3(0PF12.5)/,
     1       'ANNUAL TOT ENERGY COST  ($BIL/YR) LO MN HI= ',3(0PF12.5)/,
     1       'COST SHORT-DIST TRANSMISS (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST LONG-DIST-TRANS      (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST DISTRIBUTION         (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST ELECTRICITY GEN ONLY (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST ADDED-HYDRO-TURBS    (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST SOLAR+GEOTHERM HEAT  (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST LI-BATTERY STORAGE   (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST H2-ELEC PROD/STOR/FC (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST CSPPCM + PHS STORAGE (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST CWSTES+PCMICE STOR   (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST HWSTES STORAGE       (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST UTES STORAGE         (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST HPUMPS FOR HWST+UTES (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST INDUS FIREBRICK STOR (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST H2-PROD/COMP/STOR    (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST ALL-NONH2-STORAGE    (C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST EL+HT+HP+SDT&D+ALSTOR(C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST EL+HT+SLDT+NOHEATSTOR(C/KWH) LO MN HI= ',3(0PF12.5)/,
     1       'COST EL+HT+SLDT+H2+ALLSTOR(C/KWH) LO MN HI= ',3(0PF12.5)/)
C
  284  FORMAT('TORIGLD RES COM IND TRA AGF OTH INFLEX FLEX(TWH/YR) ',
     1        9(0PF12.5)/)
  286  FORMAT('2050BAUREGLOAD-GW LCOE$2013-C/KWH HEALTH-C/KWH  ',
     1       'CLIM-C/KWH TOTAL-C/KWH       WWS-C/KWH    WWS:BAU-ENCOS ',
     1       'BAU-EN:SOC   WWS:BAU-LD    WWS:BAU-ALL   WWS:BAU-SOCC',
     1       /,11(1X,0PF13.5))
  287  FORMAT('2050 BAUEN($BIL/Y) BAUAPMORT    BAUCLIM   ',
     1       '    BAUTOT        WWSTOT      APMORT2016    APMORT2050',
     1       '     $MIL/MORT50',/,5(0PF14.5),2(0PF14.1),0PF14.5,/)
  301  FORMAT('2050 BAUEN($/TONNE-CO2E) BAUMORT BAUCLIM       BAUTOT   ',
     1       '     WWSTOT        MILTONNE-CO2E/YR',/,6(0PF14.5)/)
  288  FORMAT('TWH-DELIV DURING SIM AFTER T&D LOSS, BEF CURT/STOR LOSS'/,
     1       'ONSHORE WIND                 = ',1(0PF13.5)/,
     1       'OFFSHORE WIND                = ',1(0PF13.5)/,
     1       'ROOFTOP PV                   = ',1(0PF13.5)/,
     1       'UTILITY PV                   = ',1(0PF13.5)/,
     1       'CSP (INCLUDING FROM STORAGE) = ',1(0PF13.5)/,
     1       'HYDROELECTRIC                = ',1(0PF13.5)/,
     1       'WAVE                         = ',1(0PF13.5)/,
     1       'GEOTHERMAL ELECTRICITY       = ',1(0PF13.5)/,
     1       'TIDAL                        = ',1(0PF13.5)/,
     1       'SOLAR THERMAL                = ',1(0PF13.5)/,
     1       'GEOTHERMAL HEAT              = ',1(0PF13.5)/)
  289  FORMAT('TWH TSUMCSTLS TREMCSTOR   FINEFFIC     ',
     1       'EFFCSP       CFCSP',/,5(0PF13.5))
  292  FORMAT('TWH TSUMPSTLS TREMPSTOR   FINEFFIC     ',
     1       'EFFPHS       CFPHS  ',/,5(0PF13.5))
  597  FORMAT('TWH    --     TWHHYD       --          ',
     1       '   --        CFHYD  ',/,5(0PF13.5))
  598  FORMAT('TWH    --     TWHPKHYD     --          ',
     1       '   --        CFPKHYD',/,5(0PF13.5))
  599  FORMAT('TWH    --     TWHBSHYD     --          ',
     1       '   --        CFBSHYD',/,5(0PF13.5))
  290  FORMAT('TWH TSUMOSTLS TREMOSTOR   FINEFFIC    ',
     1       'EFFCOLD      CFCWSTES',/,5(0PF13.5))
  293  FORMAT('TWH TSUMFSTLS TREMFSTOR   FINEFFIC     ',
     1       'EFFH2CD      CFH2GRID',/,5(0PF13.5))
  295  FORMAT('TWH TSUMHSTLS TREMHSTOR   FINEFFIC    ',
     1       'EFFHSTES     CFHWSTES',/,5(0PF13.5))
  296  FORMAT('TWH TSUMBRSTL TBRICKTWH   FINEFFIC     ',
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     1       'EFFHTBAT     CFBRICK',/,5(0PF13.5))
 297  FORMAT('TWH TSUMUGSTL TREMUSTOR   FINEFFIC     ',
     1       'EFFUTES      CFUTES',/,5(0PF13.5))
 291  FORMAT('TWH BATSTOR-LOSS TREMBSTOR REMSTOR/REMSTOR+LOST ',
     1       'EFFBAT   CYCLES        CYCPDAY     CYCPYR      ',
     1       'BATLIFE      HRMAXBAT     BATMXOUT     CFBAT',/,
     1       11(0PF13.5))
 302  FORMAT(/'HVDC-KM CAP-MW $/MW-KM FLDIS: ',3(0PF10.1),0PF10.3,
     1        '  HVDCCON-OPJOBS/Y: ',2(0PF10.0))
C
C ***************************************************************************
C                        END OF PROGRAM POWERWORLD.F
C ***************************************************************************
C
      STOP
      END
```